April 25, 1957

b. TENTATIVE DEGREES OF DRAINABILITY FOR USE IN CLASSIFYING LANDS AS TO SUITABILITY FOR IRRIGATION

In order to assign a Use Capability Class to any parcel of land, its relative drainability must be carefully determined and weighted along with other major characteristics such as soil, slope, erosion and climate.

The following degrees of drainability are so described with respect to limitations imposed by these conditions that, other factors not limiting, they correlate with land use capability classes; i.e., very good Class I, and so on through the five degrees of drainability described.

The five degrees of drainability are described with respect to depth to barriers or very slowly permeable layers, the permeability of the saturated or aquifer zone, the stratification of the soil and substratum, the depth, continuity and character of aquifers, and the natural grades available for drains. Suggested limitations for drain depths and spacings are given for each class or set of conditions.

Limitations of each factor have been compared with drainage experience and drainage recommendations in other areas. Ability of Afghan farmers to cope with drainage cannot be measured at this time. A few limited observations indicate they can, where the cost of land and water is no factor, successfully apply their own labor to land of poor drainability, although major development costs may not be economically justified by a benefit: cost ratio based on construction costs by contractors and on Afghan market prices for production from the land. The physical ability of the land to meet the minimum use requirements of the land class after complete treatment is the primary criteria used. The economic justification of developing a parcel of land may vary widely from locale to locale regardless of land class and can only be computed where all cost and production factors are known.

(1) - VERY GOOD DRAINABILITY

Barriers - No barriers exist, or, if they do exist, are found below 9 feet and are overlaid by very rapidly permeable aquifers permitting a freely draining solum of over 5' in sandy or medium soils and 6' in heavier soils, with upward capillary movement from the normal watertable broken by coarse materials.

Hydraulic Conductivity and Permeability - The soils must have not less than 0.25"/hr. nor greater than 2.5"/hr. permeability in the upper horizons and must be more open downwards so that, even with 20% percolation losses from irrigation, no perched watertables will occur. The aquifer zone should have an hydraulic conductivity of 15.0"/hr. or greater.

Stratification - The soils should have little or no stratification and be more open downwards so that gravitational water will disappear from the upper 5-foot zone within 3-5 days or less after an irrigation.

Aquifer Thickness & Continuity - The aquifer zones should be 6-10 feet thick and continuous at depths of 3-9 feet or deeper below the surface. In general the aquifers should be adequate to lower the watertable at a rate of 1 foot per day without farm drains but with lateral deep drains spaced not less than 0.3 mile (0.5 Km) apart.

Drainage Gradient - Should be greater than .001 in the deep open drains.

Tile Depths & Spacings - Generally farm drains should not be needed on the small (5-10 acre) farms anticipated. Deep, open ditch or tile, accumulator drains at a minimum of 0.3 mile (0.5 Km) may be required.

d2 - GOOD DRAINABILITY

Barriers - If barriers to downward water movement are present they should be deep enough to allow a freely draining soil section of not less than 3½ feet in sandy, 4½ feet in medium and 5½ feet in moderately heavy soils. Upward capillary movement from the groundwater table should be broken or greatly retarded by coarser materials.

Hydraulic Conductivity and Permeability - The soils must have not less than .25"/hr. nor more than 5.0"/hr. permeability in the solum. In general the soil horizons and substratum should be more open downwards and the upward capillary movement be broken or retarded by coarser materials.

Slower lenses or strata may cause minor temporarily perched watertables following irrigation but these should disappear by ½ the time between irrigations during the peak season. The aquifer zones should have a hydraulic conductivity of not less than 5.0" per hour.

Stratification - There may be moderately stratified variations in soil and substratum permeability but permeability should generally increase downward. Trapped or perched water above the 4' level should disappear with normal water use and drain spacing in the first half of the interval between irrigations in the peak irrigation season.

Aquifer Thickness and Continuity - The aquifers may be 2-6 feet thick, and lie approximately 3-6 feet below the surface but should be continuous and should allow the removal of free water to below the 4' level in 4-5 days following irrigations, provided normal water management practices are used and drains are properly installed.

Drainage Gradient - Should be not less than .001.

Drain Spacings & Depths - Normally these soils should drain with tile or open ditches at not less than 150 feet apart. Minimum depths would normally be 4½ feet for sandy, 5½ feet for medium and 6½ feet for heavy textured soils.

d3 - FAIR DRAINABILITY

Barriers - Barrier depths should be such as to allow a freely draining soil section of not less than 2½ feet in sandy, 3½ feet in medium and 4½ feet in heavier soils when drainage facilities are installed and reasonably fair water management is practiced.

The barrier must be over 1 foot lower and may be several feet lower than above depths depending on hydraulic conductivity and grade.

Hydraulic Conductivity and Permeability - The soil section must have greater than 0.14"/hr. and less than 5.0"/hr. permeability. The aquifer zones should have an hydraulic conductivity of not less than 0.5"/hr. Gravitational water should move through the soil profile in less than one-half of the time interval between irrigations in the peak use season when reasonably careful water management is practiced and proper drainage facilities installed

Stratification - May be stratified in both soil and substratum provided most of the perched free water can move out of the upper foot within 3 days and down to the desirable drawdown level within one-half of the irrigation period in the peak irrigation season.

Aquifer Thickness and Continuity - The aquifer zones may be 1 foot to 3 feet thick but should be 3½ feet or more deep. They may be semi-continuous. They must permit the desirable drawdown within one-half of the irrigation cycle in peak season, assuming conservative water management and drains at a minimum spacing of 75 feet.

Drainage Gradient - Should be over 0.00075 unless pumping and/or use of artificially graded drains is feasible.

Drain Spacings and Depths -- The minimum spacing of tile or open farm drains is 75 feet for this class. The minimum depths should be 3½ feet for sandy, 4½ feet for medium and 5½ feet for moderately heavy soils, respectively.

d4 - POOR DRAINABILITY

Barriers - Barrier depths should be over 2½ feet deep in any soil; should be 3½-4½ feet deep or deeper with moderately restrictive horizons and moderately permeable soils and 4½-6 feet deep or deeper with moderately slow aquifers and moderately slow restrictive layers above. The minimum freely draining soil depth should be not less than 1½ feet.

Permeability and Hydraulic Conductivity - The soil section may have a minimum permeability of .04"/hr. provided the soil and aquifer zones are more open downwards and no restrictive layers are present. Aquifer permeability may be highly variable but in combination with the soil and barrier depth should permit a continuous transmittal of water through the soil and into the outlet drains such that the upper 18" will drain in ½ the irrigation cycle at peak use or 3 days whichever is the longer. Generally the hydraulic conductivity of the aquifer zones must be over 0.1"/hr.

Stratification - Both soil and substratum may be stratified and have perched watertables following irrigation, provided that perched free water within 18" of the surface will move downward within ½ the irrigation cycle or 3 days and, provided that the continuous movement of water through the soil profile and into the drains is adequate to maintain a favorable salt balance for growth of tolerant legumes and grasses.

Aquifer Thickness and Continuity - May be discontinuous and less than 16" thick. A minimum continuous aquifer of 6" of very rapidly permeable (over 5"/hr.) materials may be permitted if other conditions are favorable. Perched watertables or blocked water movement may exist but the upper 18" of soil should drain out in ½ the irrigation cycle or 3 days whichever is the longer. Moderate growth of water and salt-tolerant grasses and legumes, or trees and shrubs on over 75% of the area must be feasible with careful water management and drains at a minimum spacing of 33 feet (10 meters or 1 normal border width).

Drainage Gradient - Should not be less than .0005 unless pumping and/or use of artificially graded drains is feasible.

Drain Spacings and Depths - A minimum of a normal border width of 33 feet or 10 meters is assumed the closest spacing practical under any circumstances. A minimum depth of tile or open ditch of 2½ feet is ass'med. With these minimum conditions imposed the soils and aquifers should be such as to allow a minimum drawdown of 1½ feet within ½ of the irrigation cycle during the peak use season or 3 days, whichever is longer. The movement of water through the soil into the drains and substratum must be such that a salt balance favorable to moderate production of salt and water-tolerant grasses and legumes can be maintained.

d5 - VERY POOR DRAINABILITY

Barriers - Less than 2½ feet with any soil condition above; and generally less than 3-4 feet with moderately slow permeability above or less than 5 feet with slow permeability above.

Permeability and Hydraulic Conductivity - Less than 0.04"/hr. soil permeability or 0.1"/hr. substratum permeability, or any stratified condition that will not permit removal of watertable below 1½ feet within ½ the irrigation cycle during the peak season of use or 3 days, whichever is the longer, when minimum ditch spacing is used.

Stratification - Extreme variation in hydraulic conductivity of soil and substratum lenses within 3 feet or less of the surface such that the above-described drainage requirements cannot be met.

Aquifer Thickness and Continuity - No apparent aquifers or less than 6" thickness of permeable materials in discontinuous strata.

Drainage Gradient - Less than .0005, with pumping and/or artificially graded drains not feasible.

Drain Spacing and Depth - Less than 33 feet spacing or less than 2½ feet depth.

Note: Again it must be emphasized that the above drainability classes are based on the physical criteria considered necessary to meet the requirements of the land capability classes, and do not reflect economics of development except as applied to a particular situation where all cost and production factors are known.

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c. Drainability Class Limits. The drainability class limits summarized in Table 42, are based on consideration of the adaptation of crops to different levels of drainage as well as to the physical factors affecting drain spacings, and depths. Comparison was made with a number of U. S. publications on drainage standards. The criteria assumed for Class I drainability may be somewhat too strictly drawn. Highly productive soils of Class I quality may require somewhat closer drains than indicated. At the other extreme the limits for Class IV lands permit the growth of water tolerant legumes and grasses or such crops as rice for which sub-surface drainage may not be necessary. The minimum drain depth of 2½ feet is listed in several U. S. publications. The minimum mid-tile drawdown of 18" conforms to the soil depth limitations for Class IV lands. Similar considerations were used in arriving at class limits of the other two classes. Illustrations of various drainability conditions are given in drawings following (Tables 43, 44, and 45).

d. Quantities of Water to be Removed by Drains. The quantity of percolation waters that must be removed by drains is largely a function of irrigation efficiency. Factors affecting irrigation efficiency are the capacity of the soil to hold water, the rate of intake, the care with which the field is leveled and laid out for uniform irrigation, the time and rate of application of irrigation water, and the percolation losses in the distribution system. The intake rates and storage capacities of the major soils are discussed in Chapter IV. In Chapter VII on Water Use Practices the differences in soils and their affects on planning efficient irrigation layouts will be given further treatment.

Israelson states that pumping 1/3 of the total irrigation water used in the Salt River Valley, Arizona, continues to lower the water table. Houk quotes data on ground water return flow including South Platte - .0036 cfs/acre, N. Platte - (Whalen Dam to N. Platte)-.0042 cfs/acre, California deltas - .006, San Joaquin Valley - .015, Rio Grande - .005, and San Luis Valley, Colorado - .003 cfs/acre, or generally .003-.006 cfs/acre.

Table 46, shows the rate of drain removal required for different amounts of irrigation, percentage losses and time of drawdown. As long as the water recedes to the normal depth by 1/2 the irrigation cycle some plants can stand longer drawdown periods than indicated.

e. Economics of Drainage. Several inter-related factors enter into the economic considerations of drainage. Maximum production value with minimum capital investment is of course the ideal but not always attainable goal. Where private capital is being invested for a purely profit motive careful consideration would be given to all costs and to expected returns. Where public welfare is the primary and long-term objective, the political and social urge to develop land and water resources may accept difficult and extraordinary tasks as feasible. The people of the Netherlands have struggled against the seas through wars and typhoons to reclaim lands from under the salty waters. Eight to ten years are required after the sea waters are pumped out before the lands are quite ready for use.

A piece of land may grow certain water tolerant grasses and legumes and return a relatively low income as pasture with little or no expense for drainage. On the other hand drainage properly installed and maintained may allow the production of high value crops that will over a period of years offset the costs of drainage.

Table 42

April 27, 1957

SUGGESTED DRAINABILITY LIMITS FOR LAND CLASSES IN IRRIGATED AREAS

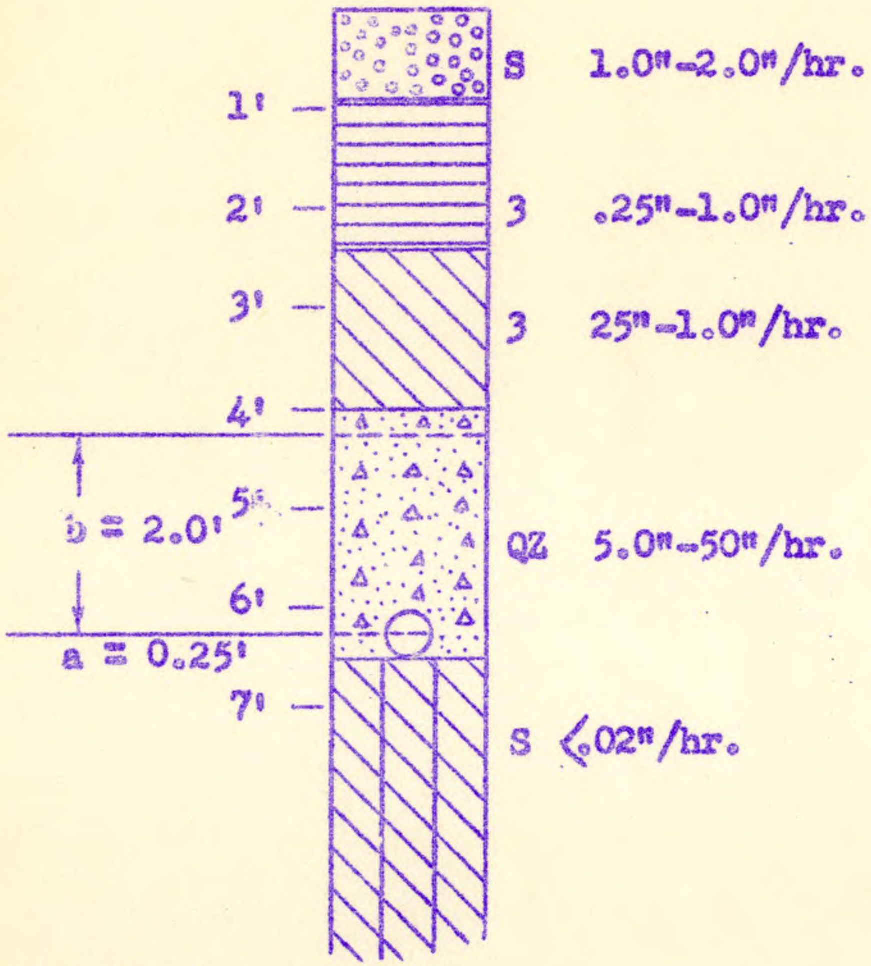
Land Class 1/	Drain Spacing (feet)	Drawdown 2/	Depth to Tile (feet)	Grade of Tile or Ditch
Class I	No farm drains req. Lateral deep drains over ½ Km. may be needed.	All areas freely drained to below 5' in medium & sandy & below 6' in heavy soils.	Only wide spaced laterals required. Depths over 8' desired.	Open ditches on greater than .001 grade.
Class II	Min. of 150'	Min. of: 3½'-Sandy Soils 4½'-Medium Soils 5½'-Heavy Soils	Min. of: 4½'-Sandy Soils 5½'-Med. Soils 6½'-Heavy Soils	Min. of .001 grade
Class III	Min. of 75'	Min. of: 2½'-Sandy Soils 3½'-Medium Soils 4½'-Heavy Soils	Min. of: 3½'-Sandy Soils 4½'-Med. Soils 5½'-Heavy Soils	Min. of .00075, unless pumping and/or use of artificially graded drains is feasible.
Class IV	Min. of 33'	Min. of 1½'	Min. of 2½'	Min. of .0005, unless pumping and/or use of artificially graded drains is feasible.
Class V	<33' (10 M)	<1½'	<2½'	<.0005 (pumping and/or use of graded drains is not feasible.

1/ These minimum requirements are computed from physical conditions which are necessary to conform with the land capability class definitions. They reflect economics of development only where costs and production are known quantities.

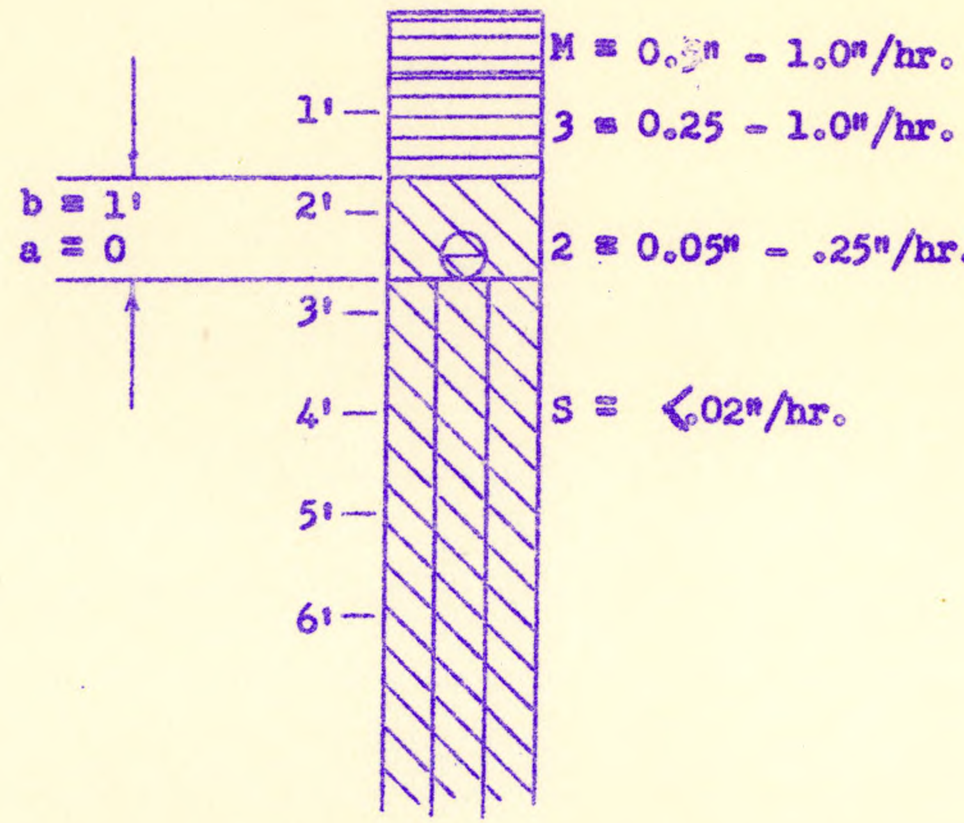
2/ Drawdown is generally assumed to be the normal depth to groundwater. However it is calculated at the point midway between tile lines or point of least recession. The time interval assumed for calculation is ½ of the time interval between successive irrigations at peak irrigation demand, or a minimum of 3 days.

Table 43

<u>Example of d-2 Drainability</u>
<u>2S33-QZ</u>



<u>Examples of d-5 Drainability</u>
<u>3M32S</u>



<u>Calculations:</u>

TRAM = 4.0", Irr. Freq. = 15 days.
Q = .002 cfs at 10% & .006 cfs at 30%

Assume drawdown = $4\frac{1}{2}$'
a = 0 or .25' b = 2.0'

$$S = \sqrt{\frac{4 \times 9\ (2^2 - .25^2)}{.006}} = \underline{154'}$$

$$S = \sqrt{\frac{4 \times 5.0\ (2^2 - 0)}{.002}} = 630'$$

<u>Calculations:</u>

TRAM = 2.5" Irr. Freq. = 8 days.
Q = .0026 cfs at 10% and .01 cfs at 30%

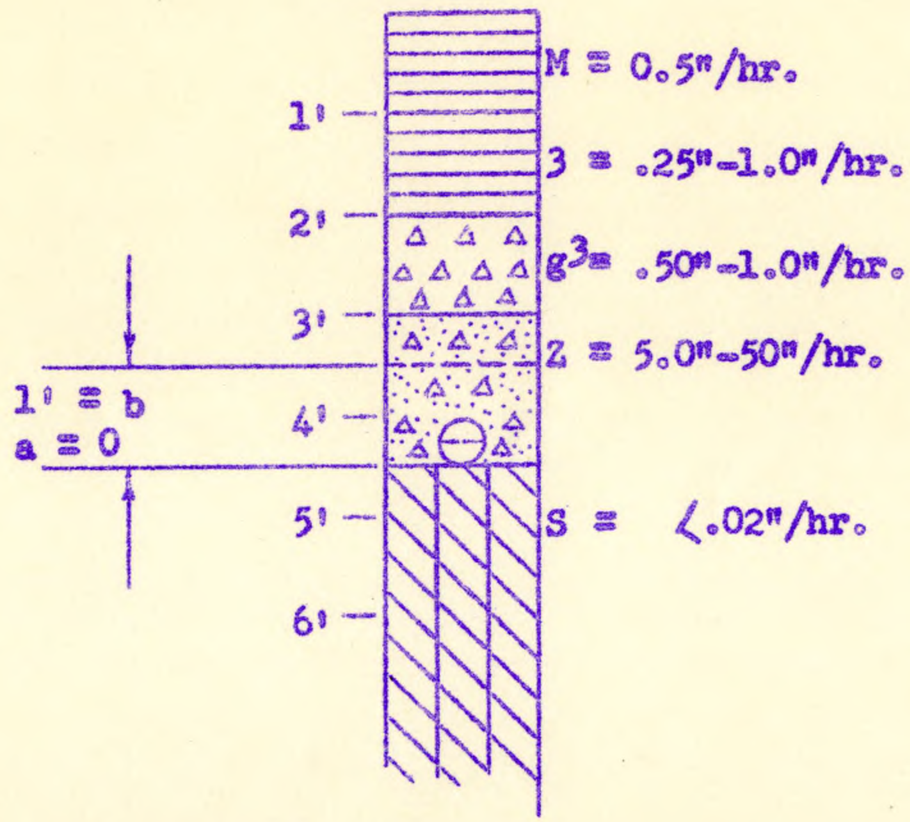
Assume $1\frac{1}{2}$' drawdown (min. for d-4)

$$S = \sqrt{\frac{4 \times .2 \times 1^2}{.0026}} = \underline{17.5'}$$

$$S = \sqrt{\frac{4 \times .2 \times 1^2}{.01}} = 9.0'$$

Table 44

Example of d-3 Drainability
2M3g3-ZS



Calculations:

TRAM = 3.75", Irr. Freq. = 14 days.

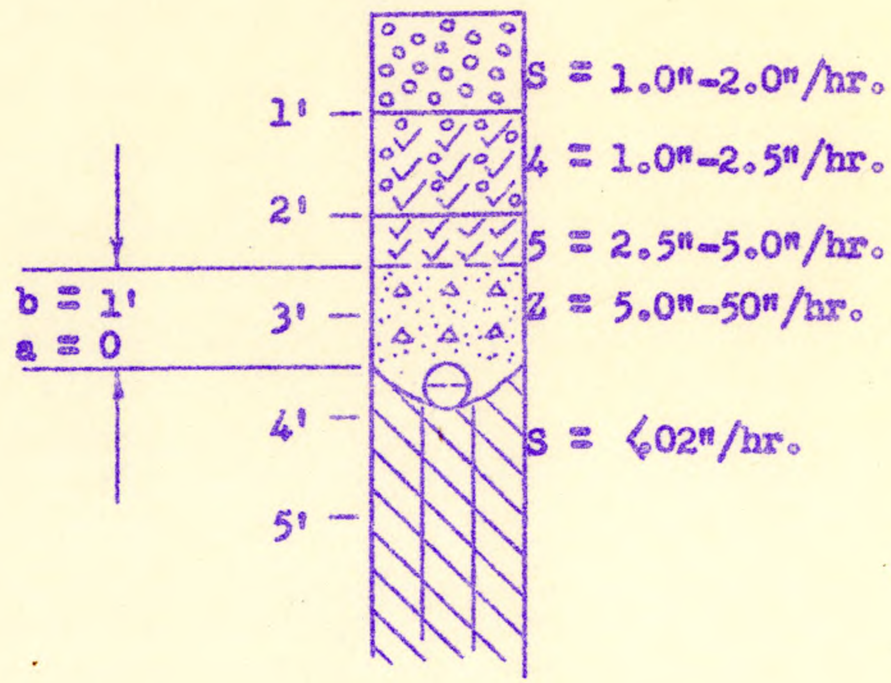
Q = .0027 cusecs @ 10% and .0095 cusecs @ 30% loss

Assume $3\frac{1}{2}$' drawdown:

$$S = \sqrt{\frac{4 \times 5 (1^2 - 0^2)}{.0027}} = \underline{87'}$$

$$S = \sqrt{\frac{4 \times 14 (1^2 \times 0^2}{.0095}} = \underline{75'}$$

Example of d-3 Drainability
3S45-ZS



Calculations:

TRAM = 2.5", Irr. Freq. = 8 days.

Q = .0026 cfs @ 10% and .01 cfs @ 30%

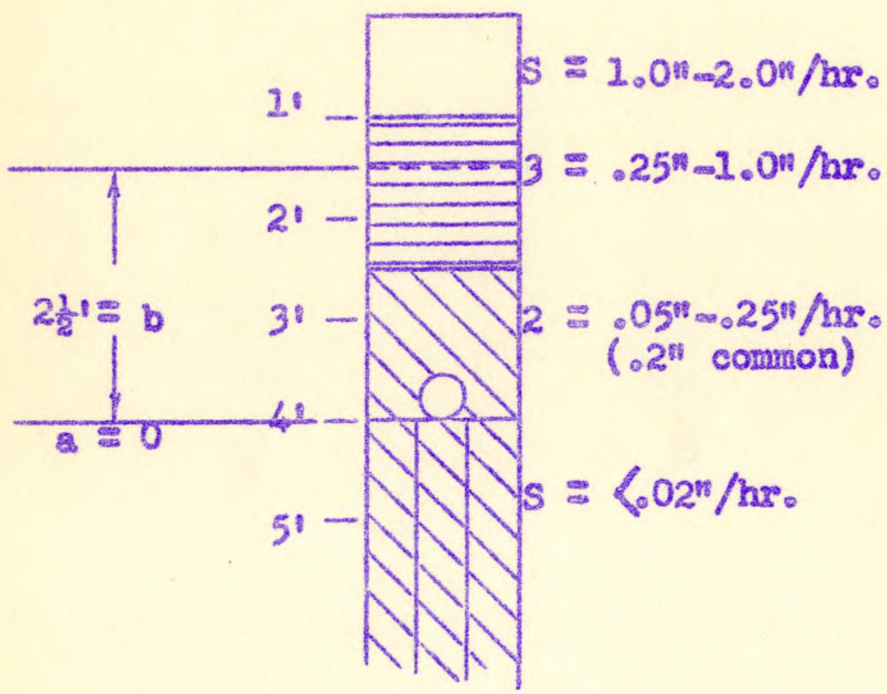
Assume $2\frac{1}{2}$' drawdown:

$$S = \sqrt{\frac{4 \times 5 (1^2 - 0^2)}{.0026}} = \underline{88'}$$

$$S = \sqrt{\frac{4 \times 14 (1^2 - 0^2}{.01}} = \underline{75'}$$

Table 45

Example of d-4 Drainability
2S32-S



Calculations:

TRAM = 4.0", Irr. Freq. = 15 days.

Q = .002 cfs at 10% and .006 cfs @ 30% loss.

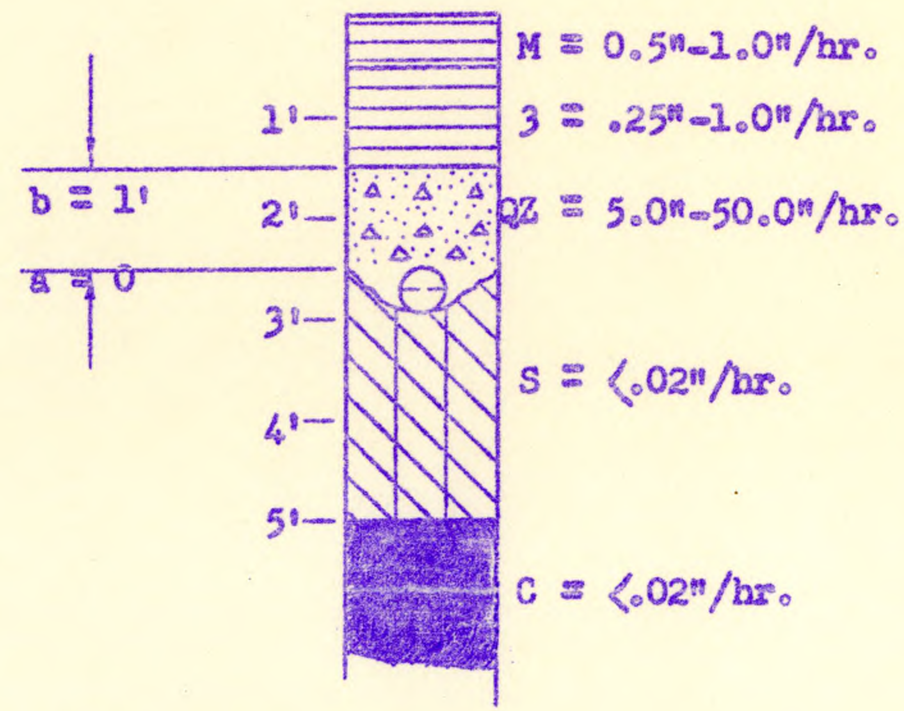
Assume drawdown = 18" or min. for d-4:

$a = 0,\ b = 2\frac{1}{2}'$

$$S = \frac{\sqrt{4 \times .2\,(2\frac{1}{2})^2 - 0}}{.002} = \underline{50'}$$

$$S = \frac{\sqrt{4 \times .2\,(2\frac{1}{2})^2 - 0}}{.006} = \underline{30'}$$

Example of d-4 Drainability
4M3-QZS



Calculations:

TRAM = 1.8", Max. Irr. Freq. = 5 days.

Q for 3" irr. = .0165 cfs = 40% loss

Assume min. drawdown of 18":

$a = 0,\ b = 1'$

$$S = \frac{\sqrt{4 \times 5\,(1^2 - 0)}}{.0165} = \underline{34'}$$

November 15, 1956

DRAINAGE TERMS AND EQUIVALENTS

(Percolation, Infiltration, Permeability, Hydraulic Conductivity)

1 Cu. inch/sq. in./hr = 15 gal./sq. ft./day (g.p.d.)
= 2.31×10^{-5} cu. ft./sq. ft./sec. (cfs, Cusec)
= 2.54 cc/cm^2/hr. (cc/hr.)

1 cc/cm^2/hr. = 0.3925 cu. in/sq. in./hr. (in./hr.)
= 5.9 gal./sq. ft./day (g.p.d.)
= 9.1×10^{-6} cu. ft./sq. ft./sec. (cfs)

1 Cu. ft./sq. ft./sec. (cfs) = 646,317 gal/sq. ft./day (g.p.d.)
= 43,200 in./sq. in./hr. (in./hr.)
= 109,728 cc/sq/cm/hr. (cc/hr.)

Table 46

IRRIGATION DRAINAGE REQUIREMENTS - CFS/ACRE *

Based on rates & frequency of irr. and percentage percolation losses.

Irr. Rate Inches	Allowable Drawdown time in days	Cfs./acre drain removal required at varying percolation losses						
		5%	10%	15%	25%	30%	40%	50%
		cfs	cfs	cfs	cfs	cfs	cfs	cfs
3	3 (72)	.0021	.0042	.0063	.011	.0125	.0165	.021
	5 (120)	.0013	.0025	.0038	.0063	.0075	.0100	.013
	7 (168)	.0009	.0018	.0027	.0045	.0054	.0072	.009
4	3	.0029	.0055	.0083	.0139	.0166	.022	.029
	5	.0017	.0033	.0050	.0083	.0100	.0133	.0167
	7	.0012	.0024	.0036	.0060	.0072	.0095	.0120
6	3	.0042	.0084	.0125	.021	.025	.033	.042
	5	.0025	.0050	.0075	.0125	.0150	.0200	.025
	7	.0018	.0036	.0054	.0089	.0108	.0144	.0178
8	3	.0055	.0111	.0167	.0278	.0334	.0445	.0555
	5	.0033	.0067	.0100	.0167	.0200	.0266	.0333
	7	.0024	.0048	.0072	.0119	.0143	.0190	.0238
10	3	.0069	.0139	.0208	.0278	.0415	.0555	.0695
	5	.0042	.0083	.0125	.0208	.0250	.0333	.0415
	7	.0030	.0060	.0089	.0149	.0178	.0238	.0298
12	3	.0083	.0167	.0250	.0333	.0500	.0667	.0833
	5	.005	.0100	.0150	.0250	.0300	.0400	.0500
	7	.0036	.0072	.0107	.0178	.0214	.0286	.0357

*C.F.S./Acre x 1.9835 = cu. ft./sq. ft./day
" / " x 0.9917 = cu. in./sq. in./hr.
" / " x14.837 = gal./sq. ft./day

TABLE 4

S. W. AFGHANISTAN CLIMATE *

June 22, 1957

MEAN ANNUAL RAINFALL

Elevation in Meters:

MONTHS	490 Chakansur	780 Marja	790 Chah-i-Anjirs	884 Farah	923 Herat	1000 Kandahar	1030 Kajakai	1110 Arghandab	1793 Kabul	2241 Ghazni	TOTALS	MEANS
JANUARY	1.0	1.69	1.24	1.04	2.44	2.49	1.44	2.43	1.21	1.63	16.61	1.67
FEBRUARY	.8	0.71	1.25	0.92	1.31	1.73	1.38	1.86	1.43	1.60	12.99	1.30
MARCH	.6	1.41	1.53	0.41	1.52	1.43	2.88	1.94	4.05	2.07	17.84	1.78
APRIL	.2	0.24	0.20	0.04	0.34	0.48	.57	0.51	3.67	0.85	7.10	0.71
MAY	T	0.02	0.16	0.05	0.17	0.22	.11	0.23	.78	1.06	2.80	0.28
JUNE	0.0	0.00	0.15	0.00	0.00	T	T	T	.21	0.36	0.75	0.08
JULY	T	T	0.20	0.00	0.00	0.14	.14	(.14)	.13	0.44	1.21	0.12
AUGUST	0.0	0.00	0	0.00	0.00	T	0	0	.14	0.08	0.23	0.02
SEPTEMBER	0.0	0.00	0	0.00	0.00	0	0	0	T	0.09	0.10	0.01
OCTOBER	0.0	0.01	0.04	0.00	T	.02	.02	T	.56	0.00	0.67	0.07
NOVEMBER	T	0.04	T	0.59	0.31	.04	.02	.01	.82	0.08	1.93	0.20
DECEMBER	.25	0.73	0.56	1.57	1.33	.74	1.16	1.57	.43	0.49	8.83	0.88
TOTALS	2.85	4.81	5.33	4.63	7.43	7.29	7.72	8.69	13.43	8.75	71.06	7.11
EFFECTIVE * RAINFALL	2.00	3.50	3.75	3.40	5.45	5.30	5.55	6.40	9.85	6.35	51.55	5.15
YEARS OF RECORD	5 (partial)	4	6	3	7	19	6	6	44	4	(103)	—

Stations arranged in order of increasing elevation. Data is from all available records. Many are incomplete and in places may be unreliable as a forecast.

* An average of 75% of the rains are above .20 and may be considered effectiva in supplying soil moisture or reducing transpiration-evaporation losses.

In the Helmand Valley it appears certain from studies made so far that production levels of most soils of the projects will be coupled with how well these lands are drained and the drains maintained. Estimates of drainage costs have ranged from as low as $30.00 per acre to as high as $300.00 per acre for various conditions encountered. In terms of repayment of costs (say @ 4½ % over a 50-year period) these require a net increase of 1 bushel of wheat per acre on the first soil and 10 bushels per acre on the second. Unfortunately some of the least productive soils, as in the case of the Nad-i-Ali, Marja and Seraj desert bench, may require the greatest expenditures for drainage. For some of the more difficult areas the best choice appears to be the growth of special crops adapted to waterlogged, saline situations.

The failure of some of the tile lines in Nad-i-Ali caused by plugging with plant roots, silting of tile or other causes has led to a belief that open drains will be best for Afghan farmers. This may well prove to be an unfortunate choice. In the first place open drains dug at proper depth and side slope are more expensive to install than tile drains. Maintenance will be much greater in the long run. The tile that were plugged with willow roots were placed not over 20 feet from fair sized willows. No water-loving trees should be within 100 feet of tile lines. The plugging of some tile by camel thorn was a cause for general dismay and a cry of failure. A few years of consistent spraying with the proper chemicals would eliminate camel thorn or any other such obnoxious plant and at very low costs. Open ditches will take land out of production at the rate of 1.5% for every line installed. Thus 100-meter spacing deletes 15%, 50-meter 30%, and 25-meter 60% of the land area. As the cost of drainage goes up, the acreage which should bear the cost of development goes down and the gross product also goes down. In the Nad-i-Ali, starting with an initial arable area of 18,500 acres, assuming the same unit price and comparing open drains vs. closed drains on a cost:production ratio, the open drains would cost @ 100 meter spacing - 1.4 times tile drains, @ 50 meter spacing - 2.03 times, and at 25 meter spacing - 6.3 times the cost of tile drains. The number of usable acres reduces to 85%, 70% and 40%, respectively, of that available. Since some lands in the Nad-i-Ali will require less than 100 meter spacing it appears impractical to consider open farm drains as a long-time solution. The extra costs for other structures and the greatly increased costs of maintenance and operation amidst this maze of open drains was not considered in the above comparison. A little common sense direction in the correct installation of tile drains and the use of a few dollars worth of chemical sprays can save millions of dollars invested in an unsightly and less productive area. Farmers can be taught how and directed to install tile drains, provided tile, gravel and technical assistance are furnished. The cash outlay could be greatly reduced and the land saved for crops which is after all the goal of the whole development program.

3. <u>RECLAMATION, TREATMENT AND MANAGEMENT OF SALINE, SALINE-ALKALI AND ALKALI SOILS.</u>

In the Helmand Valley large areas of soils are presently either unproductive or of low productivity because of an excess of salts, alkali, boron or a combination of these. The program of project development must concern itself eventually, therefore, not only with irrigation distribution and drainage systems but with measures to remove and control salinity and alkalinity, including the adoption of crops and cropping practices which will maintain as high a level of production as the non-removable alkalinity and salinity will allow.

<u>Physical Factors</u> affecting the successful reclamation and management of such soils include (1) depth and permeability of soil, (2) presence or absence of groundwater tables and character of groundwater, (3) permeability of the substratum and drainability (including outlets) of the area in question, (4) total concentration and quality of the salts present, (5) base exchange capacity and degree of sodium saturation of clays, (6) quantities and distribution of gypsum or other calcium salts in the soil and in accessible nearby deposits, (7) total salts of each kind and percent of sodium salts in irrigation waters, and (8) climatic factors affecting adapted crops, rates of evapo-transpiration and rates of drying out of soils which conduct water upward from groundwater tables.

<u>Economic or Social Factors</u> determining the feasibility of reclaiming saline or alkaline soils include, in general, the cost-benefit ratios and the national or provincial socio-economic and socio-political necessity or urge for bringing such lands into production. The latter may overweigh unfavorable cost-benefit ratios which are based primarily on agricultural production and marketing costs compared with net income from sale of agricultural products. In Afghanistan, labor is cheap and there are several months of idle time for a wheat farmer to spend on drainage work. If he can be properly directed, as for instance by the HVA and FOA teams, the actual cash outlay for on-farm drainage could be reduced by providing only the tile, gravel mantle, and engineering services. It is estimated each farmer could lay his own tile field in 3-5 years or dig narrow open drains in less time. It is urgent that this program be given serious attention, since it is obvious that drainage is a prerequisite to a sound development program in this area.

Leaching of salts and other reclamation practices also can be carried out by the farmer if he is given careful supervision and guidance. The network of major project drainage will require the best technical skills for planning, layout and construction, however.

The following discussion of reclamation, treatment and management of saline and alkali soils is based on data from various parts of the world. It is arranged in such a way that treatments generally applicable to a given soil condition can be determined from the soils maps and laboratory data on completion of detail surveys and final classification of a given area. Each tract of land will require careful study and appraisal to determine the most practical and economic methods to use but the following will serve as a general guide:

a. Drainage:

Salinity and alkalinity of the soil horizons are generally results of, (1) upward and lateral movement of solutes from groundwaters, or (2) deposition by evaporation of saline runoff waters in fields or in natural catchment basins, or (3) weathering and redeposition from geologic formations, or (4) results of irrigation or flooding with saline waters those soils which have inadequate drainage, or (5) continued irrigation with limited amounts of saline waters so that no deep percolation occurs and salts accumulate at or near the surface. In any case, success in reclamation treatment and management depends to a great extent on the adequacy of drainage.

1. Natural drainage. Deep permeable soils having no deep groundwater tables allow salts and alkali to be removed below the normal plant root zone by natural leaching or by treatment with heavy irrigations. Salts will not re-accumulate as long as there is no groundwater sufficiently high to establish capillary movement to the surface. Permeable soils over rapidly permeable sub-stratum, such as sand and gravel which offer opportunity for rapid removal of percolation waters, have ideal natural drainage. Generally such soils are not now seriously affected by salts or alkali. Where there is inadequate natural drainage, artificial drainage must be applied.

2. Artificial drainage consists of two main types, surface and subsurface. The use of these singly or in combination depends on the conditions to be met.

a. Surface drains generally are designed for removal of excess irrigation waters and storm runoff. Their design and construction is based on meeting these two requirements and they are commonly needed on most irrigation developments.

(1) Surface flushing drains for initial reclamation and management of saline or saline-alkali soils constitute a special treatment where, (a) soils have such slow topsoil or upper subsoil permeability as to limit use of deep subsurface drains, or (b) have a permanent non-removable watertable of saline waters at depths which cause recurrent capillary rise of salts, or (c) have a very heavy salt encrustation at the surface, part of which can be removed by surface flushing before starting leaching. Generally such drains are constructed in a network equal to the individual irrigation borders. Each irrigation border may be surrounded on three sides by flushing drains. These third class drains are usually 3 to 4 feet in depth with minimum cross section. The excavated soil material is used to build border dikes or excess soil may be spread onto the land and leveled.

For soils having slowly permeable upper horizons and heavy salt encrustation at the surface the general procedure would include use of maximum non-erosive heads of water. Prior harrowing to loosen and break up the salt crust and harrowing during the movement of water down the border with rapid removal of the water through the flushing drains is necessary. Only the dissolved salts and some suspended materials may be moved off the field. The water which percolates below the depth stirred by the harrow is ineffective in removing salts.

Repeated flushings will remove successively less salt. This process serves only to remove a part of the exceedingly high concentrations near the immediate surface. Following flushing by flooding, the land should be allowed to dry and crack, then be rough-plowed or ripped and cross checks installed for leaching. Gypsum should be applied to alkali areas at this time.

Leaching may require some time if the subsoils are slowly permeable. After standing for long periods, water should be drained off allowing for drying and cracking to take place. Then fresh water may be added. If rice is grown as a reclamation crop, stagnant waters must be drawn off into the surface drains and fresh water added as needed for rice culture.

b. Subsurface drainage includes three general types: open drains, covered or tile drains, and pumps. Generally all main outlet drains for an area will be of the open type. The use of open 2nd and 3rd class (on-farm) drains is less desirable than tile drains because of, (1) greater excavation costs, (2) greater difficulty and cost of maintenance, (3) increased costs for surface distribution systems, roads and other surface structures, and (4) removal from cultivation of considerable land which could otherwise be in crops. On the other hand open farm drains may be necessary where (1) slowly permeable layers alternate with permeable layers in such a way that an open drain would be more effective, (2) surface flushing and partial subsurface drainage must be combined, or (3) the cost of tile drainage exceeds the combined costs of open drains described above, or (4) tile cannot be had and farmers do not understand tile installation or maintenance of tile drains including control of plants which clog drains by deep root growth. Each set of local conditions must be carefully weighed before recommending the type of drains or combination of types to be used.

c. Pumping for drainage. (1) Pumping as a means of lowering groundwater tables may be feasible, (a) where deep, slowly permeable silts extend below practical tile or open drain depths but have no barriers and extend to good aquifers in the groundwater table, (b) where artesian pressures can be removed and, (c) where irrigation by pump water is feasible and can help offset the costs of drainage by this method.

(2) Artesian water can also be released by gravel sumps into deep open drains or tile drains. In some cases rock may limit the practical depth of excavation and yet may confine water under pressure. Wherever fissures occur this water will be forced upward into the soil creating local wet areas which are not relieved by open drains or tile. In such cases it may be possible to blast thru the rock in the bottom of the ditch and construct a gravel-packed "well" or sump into the aquifer below the rock. Water will then rise and flow in the open ditch or tile drain and help relieve the hydrostatic pressure. Attempts should be made to locate any sources of artesian water such as canal leakage or wastage of water farther up the slope which can be relieved at the source.

d. Reduction of water percolation losses. One of the most urgent needs in all projects and one that will greatly reduce the cost of construction and maintenance of drains is the careful control and use of irrigation waters. Studies of farmer irrigation in Nad-i-Ali in 1956 revealed an average efficiency of 20-30%. Not much of this waste water ran off the surface so that 60-70% of all the water used by the farmers was entering into the groundwater table. The ratio of con-

ductivity of irrigation water and drainage (groundwater) indicates that 10% percolation losses could maintain a suitable salt balance. Often 6" was put into a check-basin having only 2" available water capacity. Studies made in the dry year of 1955 by ICA showed the Patow Canal to be taking in 300-400 cusecs at the upper end after wheat harvest and when 100-150 cusecs, with reasonable efficiency, would have amply served all crops.

Measurements on a 19-kilometer stretch of the large Canal in 1953, before lining, showed losses of 50 cusecs out of 300 cusecs entering the upper end of the measured section. Some irrigation ditches run day and night when not a farmer is in the field. All of these illustrate the intolerable wastage of water which aggravates the drainage and salt problems of the Helmand Valley. Proper allocation and distribution of water on regular rotation irrigation schedules would do much to reduce water wastage. Lining of canals, puddling clay into sub-laterals and farm ditches and using better leveling and irrigation techniques would all materially lessen the burden of drainage, reclamation and maintenance necessary for successful use of the land. This is a contribution to Afghan agriculture that can be achieved only gradually but thru patient teaching and demonstration, and through organization of responsible local authority with adequate technical guidance.

The Afghans have in only very few instances shown that they understand the need for drainage. In the Seraj, where a few farmers have dug relatively shallow open ditch drains, some formerly barren, highly saline-alkali lands have been put into cultivation. Generally it appears from observation and mapping that irrigated tracts are bordered by non-irrigated tracts where the salts can accumulate. If waterlogging forces abandonment the farmer moves to another site. However, it also appears that unless the watertable remains too high many saline soils can be leached and crops raised. Therefore the chief cause of failure appears to be inadequate drainage rather than extreme difficulties of leaching and removal of alkali. Once the drains are properly installed the farmers can under guidance of HVA and ICA proceed to do reclamation work with their own labor as the principal cost item. The results of several reclamation trials conducted to date on very severely saline-alkali lands indicate that all but the heavy very slowly permeable clays can be leached of excess salts and the exchangeable sodium reduced enough to allow crop production. See Table 47 .

b. - Leaching:

Leaching constitutes removal of soluble salts from the root zone by movement of water thru the soil profile. Preferably, water should move into underground aquifers or drains which carry the salts away from the area permanently.

1. Salt Balance. More salts must move out of an area than are added by surface irrigation if the leaching program is to be successful in permanently removing salts. For example 1 acre foot of Arghandab river water, considered of excellent quality, will add 0.1 tons of harmful salts to a soil. The average annual application is about 3½ acrefeet per acre. The harmful salts added would be .34 tons per acre of soil. To maintain a favorable salt balance, assuming 20% overall percolation losses, the groundwater moving out of the area must carry at least 380 parts per million of harmful salts or about 5 times as much

Table 47

SUMMARY OF LEACHING TRIALS

7/21/57
Page 1 of

Trial # or Plot	DEPTH	Original Condition ECx10³	Original Condition ESP%	Changes With Successive Leaching: 2 Ft. ECx10³	2 Ft. ESP	4 Ft. ECx10³	4 Ft. ESP	6 Ft. ECx10³	6 Ft. ESP	8 Ft. ECx10³	8 Ft. ESP	Feet of Water Req. to Correct ECx10³	Feet of Water Req. to Correct ESP
[illegible], 1956 Loc. 515.6, N-03.0, Photo 34-113, Soil: 3M36S5S5	0-7"	67-92 (35)	34-54 (44)	7.7	11	5.7	8	—	—	—	—	4	2
	7-12"	20-50 (35)	27-55 (38)	11.2	16	6.1	8	—	—	—	—	4	2
	13-20"	15-35 (27)	26-32 (29)	11.4	28	6.5	18	—	—	—	—	4	4
	21-28"	16-32 (22)	29-33 (31)	24.2	27	5.8	19	—	—	—	—	4 ≁	(6)
Tarnak Area - 1954, Location 342.894.5, Soil: 1M22X P5S5	1954 1st Foot	52	58	Untreated 1/				—	—	1.3	9	4	4
				Gyp = 15% of req.				3.2	5	—	—	4	4
				Gyp = 45% of req.				—	—	3.2	4	4	4
	2nd Foot	34	45	Untreated				—	—	2.0	4	6	inc
				15%				2.1	25	—	—	6	6
				45%				—	—	2.2	5	6	6
	3rd Foot			Untreated				—	—	2.2	62	6	inc
				15%				2.4	50	—	—	6	inc
				45%				—	—	2.4	35	6-	10
	4th Foot	8	63	Untreated				—	—	2.2	56	6	inc
				15%				3.2	50	—	—	6-	inc
				45%				—	—	2.5	46	6-	inc
	5th Foot	3.1	64	Untreated				—	—	1.5	60	6-	inc
				15%				2.0	61	—	—	6	inc
				45%				—	—	2.6	50	6	inc

1/ Untreated still @ 0.1" perc rate after 23 days, .16" avg.; Gypsum improved rate to .32" last 10 days. Arghandab water contains 900# gypsum per acrefoot and would in 5-10 years reclaim above soil to 5 feet. In meantime leaching alone would allow crops to grow.

SUMMARY OF LEACHING TRIALS

Trial # or Plot		Original Conditions		Changes With Successive Leachings								Feet of Water Req. to Correct	
				2 Feet H2O		4 Feet H2O		6 Feet H2O		8 Feet H2O			
		$ECx10^3$	ESP	$ECx10^3$	ESP	$ECx10^3$	ESP	$ECx10^3$	ESP	$ECx10^3$	ESP	$ECx10^3$	ESP
IDA Expt'l. Farm Lashkarga - 1954 Loc. S27.5 to 28.5, W28.7 to W29.0 Soils 1M34 P5S5, 1M3P5S5, 1S3 P5S5	1 Ft.	53.5	65	12.5	22	7.00	21	5.31	10	5.08	10	4½	4-6
	2 Ft.	27.2	58	18.8	39	6.04	36	4.42	21	3.80	15	4½	8
	3 Ft.	13.2	45	20.5	43	5.90	43	4.82	35	4.39	34	6½	(inc)
	4 Ft.	8.8	38	16.3	42	8.64	42	5.04	37	4.54	46	8½	(inc)
	Note:	While lab. permeability showed low rates, field permeability in the trial plots continued at a satisfactory rate. Gypsum in the soil varied from 0-17 milli-equivalents per 100 gms. but seemed to have no quantitative relation to leaching, reduction in ESP or final infiltration rate.											
N. Arghandab 1953 1M32 P5S5 - AX Loc. E57.75-S36 (Summary of 20 Plots)	1 Ft.	24.9	63	4.2	50.0	4.2	37	3.9	40	9.0	50	2	(inc)
				7.8	24	9.1	24	5.9	21	7.6	21	(6)	(6)
	2 Ft.	6.9	27	3.8	50.0	4.25	22	5.0	27	7.0	32	2	4
				4.2	30.0	6.1	36	5.6	27	4.8	30	2	(6)
	3 Ft.	3.5	16	3.2	25.0	3.1	(62)	5.0	17	3.3	13	2	6
				3.2	20	3.6	20	3.7	19	3.4	22	2	(4-6)
	Note:	These plots were never completed because of inaccessibility. Applications of 8 tons of crude gypsum (33% $CaSO_4$) maintained a satisfactory permeability rate. The rate without gypsum dropped to .07"-.12"/hr. with 8 feet of water applied. The resampling was 6 months after leaching - when due to high water tables, some reversion had occurred.											

harmful salts as the irrigation waters bring in. Where saline areas are to be leached the drainage waters are likely to be unsuitable for re-use for a number of years unless diluted by re-mixing with diversion from the main supply. Analyses of drain water effluent from the Nad-i-Ali project have been made since 1953. These drains are carrying 2 to 12 tons of salt per acre-foot while the irrigation water entering carries about 0.39 Ts/A.F. On 8/7/55 a measurement of drain flow was made above the Marja bridge crossing and samples taken for analyses. Studies from these data and irrigation water entering in August indicated 60 tons of salt (13 tons sodium salts) entering the project and 385 tons (210 tons of sodium salts) being carried away daily. A large part of the Nad-i-Ali area contained .5%-1.5% salt in the upper foot of soil before development in 1952. The 1956 soil survey showed 12,500 acres relatively free of salts. Thus some improvement has occurred with a minimum of drains and a high watertable. When the farm drains have been properly installed it is expected that the rest of the area can be reduced in salts and a favorable salt balance be maintained. That several times as much sodium salts are moving out as are coming in is a favorable situation. It is noted also that the concentration of salts in the tile effluent has dropped about 50% since the drains were installed. (See Chart LD 135).

2. Levels of leaching and plant tolerance. A common mistake in reclamation of saline or saline-alkali soils is the assumption that diking and adding water is all that is necessary. This is far from the facts if a successful job is to be accomplished. Soils vary from conditions which are extremely costly and difficult to reclaim to those from which excess salts can be reduced and cropping started simply by giving one heavy pre-irrigation in preparation for normal cropping. One can save time, worry and disappointment by having all the facts at hand before attempting to reclaim an area. A detail soil survey accompanied by laboratory analyses and field infiltration and leaching trials will help to establish the kinds and quantities of salts to be removed, the probable amount of water and time required for leaching and the necessity for soil amendments during the leaching process. A detail drainability survey is needed to determine the extent of drainage facilities required to handle the leaching water and prevent waterlogging the area. When the conditions pertaining to a given area have been evaluated the extent to which reclamation may be accomplished by different techniques may then be weighed against probable cost and returns.

a. Land drainability and reclaimability. Not all land can be leached and drained completely. Shallow soils over impervious materials will normally have a high watertable under irrigation regardless of how close the drains may be spaced. Deep soils underlain by thick layers of silts and fine sands may continually concentrate salts at the surface by capillary movement from rather deep watertables. Since agricultural production is the primary goal of land development, the soils in S. W. Afghanistan have been divided as follows with respect to reclamation:

(1) The salt content may be reduced and maintained at low levels and the groundwater maintained sufficiently deep below the surface that all crops climatically adapted can be grown.

SUMMARY OF LEACHING TRIALS

Soil Type Trial or Plot Loc.	Depths Sampled	Original Conditions ECx10^3	Original Conditions ESP%	4 Ft. ECx10^3	4 Ft. ESP%	6 Ft. ECx10^3	6 Ft. ESP%	Me/100 gm. Gypsum	Feet of Water Req. to Correct ECx10^3	Feet of Water Req. to Correct ESP%
Plot #1 Tarnak Area Loc. Photo 23-3566 Mapped 1M33 S2 Analyzed 1F23 PS5 11/5/56 - 1/7/57	0-6"	38.1	24	4.9	6.5	2.5	8.0	3.65	4	4
	0-7"	48.9	47.3	4.8	7.0	4.3	5.5	3.15	4	4
	5-9"	13.9	42.1	4.6	27.0	1.9	22.0	0	4	6
	7-13"									
	9-12"	30.5	33.0	6.9	27.0	3.2	13.0	0	6	6
	12-14"	12.7	32.4	6.6	25.5	3.7	21.0	0.03	6	6
	12-18"									
	13-18"	18.6	37.3	9.0	20.5	4.4	6.5	0.4	6	6
	18-35"	10.6	32.0	—	—	4.3	25.2	0.43	6	8
		17.8	28.0	—	—	3.4	5.5	0	6	6
Plot #2 Tarnak Loc. Photo 23-3629 Site #1 Soil Symb. 1H12X-PS5 11/19/56 - 2/9/57	0-6"	71.5	67	4.6	10.5	24"-30" Water	Note: Because of extremely slow permeability, .006-.04 inches per hour this test was abandoned after two feet of water had been applied.			
	6-12"	31.2	50	3.6	35.5					
	12-18"	13.3	49	20.2	49					
	24-36"	19.0	41	32.9	56					
	36-48"	35.1	43	33.9	61.5					
Plot #3 Tarnak Loc. #2 Photo 23-3629 Map. 1M22XPS5 Anal. 1F23XPS5 11/26/56 - 2/25/57				2 Ft.		3 Ft.		Me/100 gm.		
	0-6"	28.2	29.0	2.8	6.8	3.4	8.2	19.1	2	2
	6-12"	20.1	29.4	4.8	6.3	4.6	7.8	6.6	2	2
	12-24"	17.1	29.4	6.4	13.3	5.8	12.1	12.8	3	2
	24-36"	14.2	28.7	8.5	13.3	7.3	17.9	1.12	3	2
	36-48"	12.5	32.0	—	—	3.8	15.0	0.0	3	3

Effect of Continued Irrigation and Drainage on Salt Content of Ground Water in Nad-i-Ali Project.

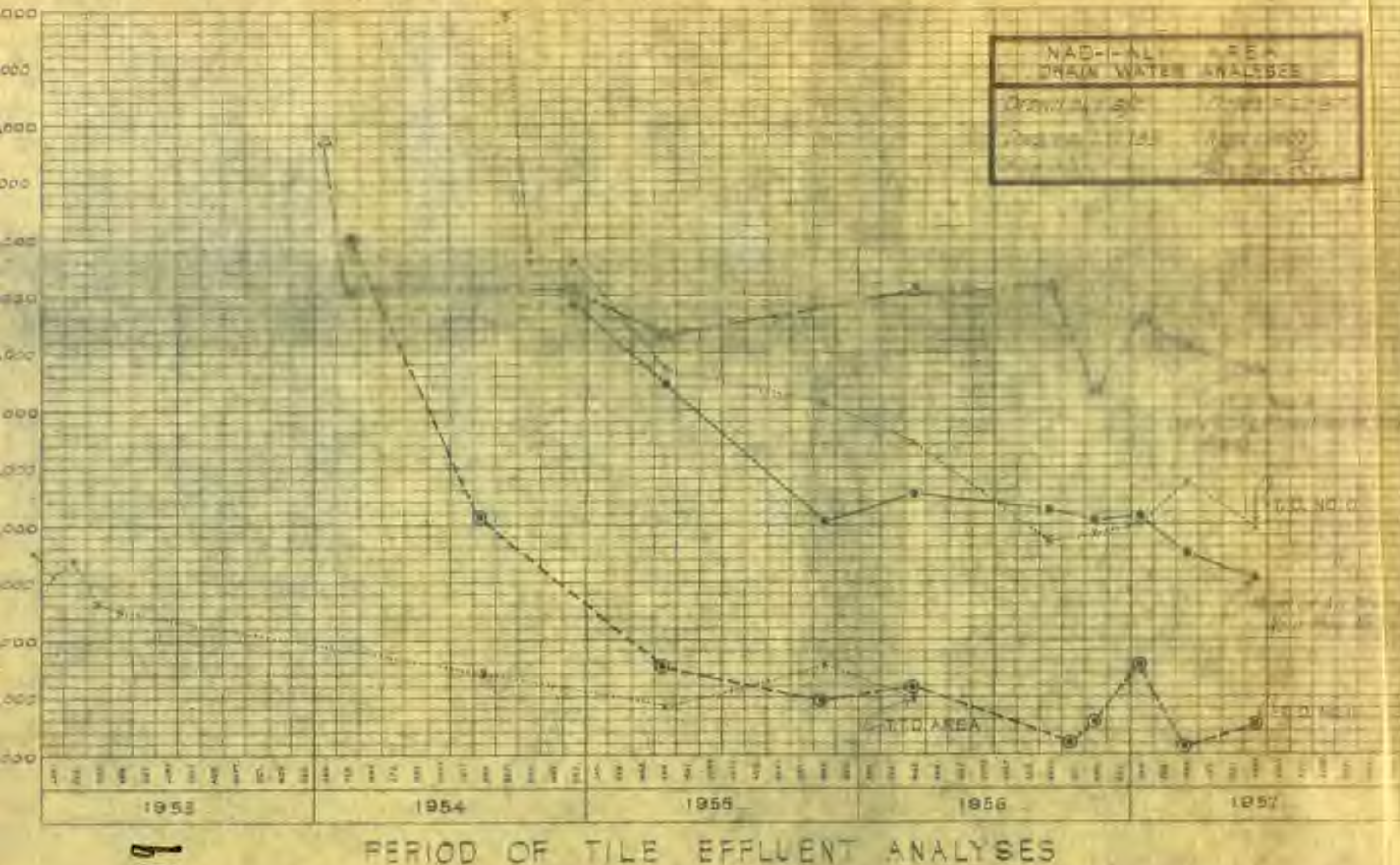


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TABLE 5

July 7, 1957

CLIMATE - FREE WATER EVAPORATION FROM SURFACE PANS

Inches

Month	Est. Citrus Cons. Use	Chakansur	Maria	Lashkargah	Chah-i-Anjira	Kandahar	Kajakai	Arghandab	Kabul	Average
Jan.	0.7	2.61	2.59	2.48	1.87	1.72	1.23	2.13	1.89	2.06
Feb.	1.00	3.56	4.68	3.59	2.54	2.57	3.31	1.76	2.71	3.09
Mar.	1.55	4.54	6.77	6.12	4.09	3.87	3.94	3.18	4.56	4.63
Apr.	2.50	6.93	7.99	9.56	7.57	6.53	8.00	6.00	6.65	7.40
May	3.75	11.29	15.01	15.36	10.65	9.00	12.95	7.24	9.05	11.31
Jun.	4.20	19.05	15.66	9.19	12.63	10.07	15.26	8.60	12.91	12.62
Jul.	4.75	20.49	18.28	11.42	12.51	10.75	15.45	8.58	15.59	14.13
Aug.	4.15	16.19	17.24	10.47	11.07	10.24	14.27	8.47	11.81	12.44
Sep.	3.15	12.63	10.94	7.19	8.16	7.53	11.28	6.42	11.96	9.52
Oct.	2.10	8.53	8.01	3.80	4.82	5.22	7.81	5.44	6.81	6.30
Nov.	1.65	5.49	6.53	3.18	3.46	3.12	4.41	3.63	4.60	4.30
Dec.	1.25	3.74	3.73	1.99	2.24	1.90	3.27	2.37	2.16	2.67
TOTALS	30.55	115.05	117.43	84.35	81.61	72.52	101.18	63.82	90.70	90.47
AVG. MO.		[illegible]	9.78	[illegible]	6.80	6.06	8.43	[illegible]	7.55	7.53

NOTE: Data from U.S.D.A. Farmer's Bulletin 1876 (April 1941) indicates transpiration use by citrus trees is about 1/3 of the mean monthly evaporation from a free water surface.

(2) The watertable may be lowered and the salinity and alkalinity reduced and held at a level permitting good production of most of the common field crops and the more tolerant deciduous fruits and vines. Deep-rooted trees and sensitive crops may not do well.

(3) The watertable level and/or saline-alkali conditions of the soil can be lowered and maintained at levels permitting the growth of tolerant field crops such as wheat and clovers. Few sensitive crops would grow well.

(4) Only crops which are very tolerant to both high watertables and salts would do well. Crops of small grains grown in rotation with tolerant grasses and legumes would be a typical use of this group of soils.

(5) Certain conditions may permit the growth of specialized crops even though subsurface drainage might be impossible or impractical. Certain varieties of rice have been grown in heavy clay soils of low permeability and very poor drainability. This crop can be transplanted into a field covered with water and kept that way during its 3-5 month growing period. Transplanting minimizes damage to emerging seedlings by salts and alkali. There is need of surface drainage to provide the slow movement of fresh water through the basins. The surface must be drained and allowed to dry to facilitate harvest. Excess salts at the surface may be reduced by repeated flushing and drainage. Dates have been grown on soils having 1-2% salts and have been irrigated with sea water. Certain varieties of barley have been grown in soil solutions of 1% salts. It is possible, therefore, that conditions considered hopeless for reclamation for ordinary farming may have special uses. Generally such lands are not recommended for present development in the Helmand Valley, however.

c. Leaching Techniques and Procedures - Land Treatment:

1. Land Preparation.

a. Carefully level each basin so that no high places permit salts to rise by capillarity, and to get uniform leaching.

b. Prepare broad stable dikes of 8"-15" settled height if the soils are heavy and a long period of leaching is contemplated.

c. Deep chisel to break up hard pans or sodium pans, at the same time mixing in gypsum, sulfur or other amendments, if needed. Sometimes natural shallow gypsum layers may be mixed with the soil by deep plowing. This would hasten infiltration and is especially helpful if the topsoil is alkaline but the next layer has excess gypsum.

d. Soils of high clay and calcium content and of slow permeability should be alternately leached (1'-2' of water) and allowed to thoroughly dry and crack. Such soils should not be plowed when wet.

2. Application of leaching water.

a. The water should preferably be low in sodium salts but contain

ample amounts of calcium salts which would promote soil structure, remove alkali and improve permeability. Soils of naturally good permeability affected only by normal salts do not need the high calcium water. Finely ground gypsum if needed can be introduced into the irrigation water at the head gate nearest the block to be leached or may be mixed into the soil as in 1 (c) above.

b. The amounts of leaching water required and the time required to leach vary widely with the soil texture, sodium saturation percentage, permeability, presence or absence of high salts and gypsum and the rate at which groundwater can be removed. A test plot on the Seraj leached with two feet of water and required only 3-4 days. Another test plot in the Tarnak required 8 feet of water and 90 days of application. In the Tarnak leaching experiment the use of Arghandab water alone was enough to reclaim the land to a point where cropping could begin. The gypsum did aid in lowering the alkali and maintained a more open soil, however. Since only the construction of basins and application of leaching water over periods of 1-3 months is all that is necessary to prepare the land for its first crop, assuming installation of drains, it does not appear that this program is beyond the abilities and resources of most settlers when given proper guidance. Where alkali conditions appear, they may be improved by gypsum which is commonly locally available. In extreme cases several years of alternate leaching and drying and growth of reclamation crops is necessary. The polders of the Netherlands are said to require 8-10 years before they are safely reclaimed from the sea to crop production.

Table 47 shows the results of several leaching trials in the Helmand Valley. Reasonable initial reclamation of some rather difficult soils was accomplished without gypsum and without artificial drainage. It must be pointed out, however, that drainage and careful irrigation to control groundwater levels is an essential part of maintaining and continuing to use these reclaimed lands.

The U.S.D.A. Salinity Laboratory has stated that soils which can transmit water continuously at 0.04" per hour or higher can be reclaimed. Table 48 summarizes water intake rates from infiltration, leaching and irrigation trials of S. W. Afghanistan soils. Over 250 cases are included. The data show that some high sodium clays and silty clays fell below this level but all other textures remained sufficiently permeable for reclamation with or without gypsum. Leaching required from as low as 24 hours to 570 hours. A heavy silty clay soil of the Tarnak dropped to .006"-.04" per hour on leaching. Such a soil is not recommended for use.

c. As long as the rate of intake stays above .1"/hr. (.25cc) leaching should be continued. If the rate drops below this it is advisable to discontinue leaching, allow the soil to thoroughly dry and crack and if possible chisel deeply before resuming leaching.

d. Boron in Soils. Soils tested in several of the project areas were found to contain soluble boron salts. Boron is essential for plant growth in minute quantities but becomes toxic to some crops when in concentrations amounting to 3 parts per million or higher. Relative tolerances to boron are not well established.

TABLE 48

INFILTRATION PROPERTIES OF SOILS June 27, 1957

FIELD STUDIES OF WATER INTAKE RATES OF S. W. AFGHANISTAN SOILS

Group (Textural)	Textures Included	Normal Soils 1/		High Sodium Soils 2/			
				With Gypsum 3/		Without Gypsum 4/	
		Mean Initial 5/	Mean Final 6/	Mean Initial	Mean Final	Mean Initial	Mean Fin.
Mod. Coarse Textured 7/ (36)	Loamy Sands to Sandy Loams	Norm= 2.45 Max.= 4.65 Min.= 2.30	Norm=1.00 Max.=1.84 Min.=0.55	No Data			
Med. Textured Soils (144)	Loams, Sandy clay loams, Silt loams	Norm=2.15 Max.=3.65 Min.=0.95	Norm=0.45 Max.=1.50 Min.=0.25	Norm=1.15 Max.=2.25 Min.=0.60	Norm=0.30 Max.=1.75 Min.=0.04	Norm=1.00 Max.=2.50 Min.=0.60	Norm=0.15 Max.=0.25 Min.=0.04
Mod. Heavy-Textured (62)	Clay loams, Silty Clay loams	Norm=1.55 Max.=3.25 Min.=0.60	Norm=0.28 Max.=0.65 Min.=0.18	Norm=1.15 Max.=2.00 Min.=0.60	Norm=0.20 Max.=0.55 Min.=0.06	Norm=1.00 Max.=2.00 Min.=0.60	Norm=0.10 Max.=0.19 Min.=0.05
Heavy-Textured Soils (24)	Silty Clays to Clays	No Data - -		Norm=0.75 Max.=1.50 Min.=0.70	Norm=0.06 Max.=0.20 Min.=0.03	Norm=1.50 Max.=2.00 Min.=0.50	Norm=0.045 Max.=0.09 Min.=0.02

Footnotes: Data is taken from double-ring infiltration tests, basin leaching trials and irrigation trials.

1/ Normal soils containing generally less than 15% exchangeable sodium.
2/ Containing more than 15% exchangeable sodium.
3/ Gypsum added or present in fair to high quantities.
4/ Generally no gypsum added - may or may not be present in soil.
5/ Rate during first few minutes to one hour.
6/ Steady rate achieved after several hours run.
7/ Numbers in parentheses indicate the number of tests or combinations of tests used in computing the values given in the table.

Experiments in the Coachella Valley, California (Reeves etal, Hilgardia Vol. 24, Sept. 1955) showed that oats began to be affected around 5 ppm and were reduced 50% in yields at 15 ppm. Analyses of soils in the Shamalan Valley which were heavily infested with scrub salt cedar (Tamarix gallica, T. Hispida and others) ran as high as 100-120 parts per million of boron. Shown below is the distribution of boron in various Helmand Valley soils as compared to the relative tolerance of common Afghan crops interpreted from analyses and field observations.

Table 49

Boron Content of Soils Tested

(No. of Samples Tested)

Area	0-3 ppm	3-5 ppm	5-15 ppm	15 ∠ ppm
Chakansur	37	13	12	2
Darweshan	4	5	3	1
Lashkarga Farm	23	17	16	2
Nad-i-Ali	4	3	4	0
Seraj	35	25	30	1
Shamalan (Bohlen Tr.)	3	0	4	12
Tarnak	28	7	5	0
Total	134	70	74	18
% of Total	42.2	23.5	24.7	6.6

Relative Plant Tolerance to Boron Salts

Tolerant	Semi-Tolerant	Sensitive
100 ppm	18 ppm	5 ppm
Athol (tamarix gallica)	Sunhemp	Walnut
Ghaz (tamarix aphylla)	Cotton	Garden Peas
Toona Ciliata	Tomato	Snap Beans
Asparagus	Navy Bean	Plum
Date Palm	Barley	Apple
Bermuda Grass	Wheat	Grape
Tall Wheat Grass	Sudan	Fig
Beets	Milo	Peach
Alfalfa	Guar	Apricot
Melons	Corn	Orange
Tall Fescue	Oats - (15)	
Clovers	Pumpkin	
Egg Plant	Squash	
Broad Bean	Pomegranate	
Onion	Field Beans	
Lettuce	Peppers	
Carrot	Sweet Potato	
18	6	3 ppm

* Upper plants most tolerant in each column, lowest least tolerant. Concentrations in parts per million estimated roughly to cut growth or yields 50%. This is based on very inadequate data and can only be a general guide as to crop selection.

Leaching trials indicate that boron salts move out of the soil during leaching slower than do the normal salts which occur in saline lands. For this reason areas containing high boron may need 1-3' more water than normal for the leaching process. Tests at Lashkarga Farm plots showed that soils with an average of 16.6 ppm boron (range of 9.4-27.0) had after 6 feet of leaching water an average of 2.7 ppm in the 1st foot and 4.9 in the second foot (range of 2.0-4.2 and 1.5-9.5, respectively). After 8 feet of water the first foot averaged the same but the 2nd foot average was reduced to 3.9 with a range of 2.2-6.0 ppm.

The following graph is inserted to show the behaviour of one group of soils on leaching. Soluble salts move out quickly so that 1 foot of water per foot of soil is normally adequate. The exchangeable sodium percentage dropped less rapidly in the first two feet and sometimes increased in the 2nd and fourth feet. To reduce the first two feet to a safe level required 8 feet of water or 4 feet per foot. Boron was lowered at about the same ratio as exchangeable sodium, i.e., 3-4 feet of water per foot of soil was required.

d. - Cropping and use of Saline Lands:

1. Initial Cropping. One does not have to wait until the salts are reduced to less than 4 millimhos conductivity and to a sodium percentage less than 15% and to a pH less than 8.5 - all desirable levels - before beginning to grow crops. As a matter of fact growing certain crops hastens the reclamation, improves the soil and brings some returns to the farmer during the reclamation period. Some of the plants which may be grown are:

a. Early stages with high salts and alkali - atriplex (saltbrush), cyperus laevigatus (saltreed), cynodon dactylon (Bermuda grass) or any other imported or local plant that will grow. This adds organic matter and opens up the soil by root channels. The fleshy leafed saltbush plant removes considerable salts in the plant foliage if harvested and carried off the land.

b. After the first heavy salt concentration is removed, such crops as barley, bermuda grass, tall wheatgrass or any crops that will permit the application of large amounts of water can be grown. Rice is especially good for this purpose since a very useful and highly prized grain crop can be grown while the land is being leached. However, since rice requires 3-5 months of inundation, soils of even .04"/hr. infiltration rate can percolate 7 to 12 feet of water. This crop only needs be grown for reclamation purposes on the deeper, heavier soils of slow permeability. Rice will grow better if the soil contains excess quantities of gypsum or gypsum is added.

c. After the salts and alkali are reduced to where soil building crops can be grown:

(1) if still affected by high watertables, use strawberry clover, trifolium alexandrium, birdsfoot trefoil, sunhemp or any soil building crops tolerant to saline-alkali conditions and high groundwater.

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Revised
7/24/57

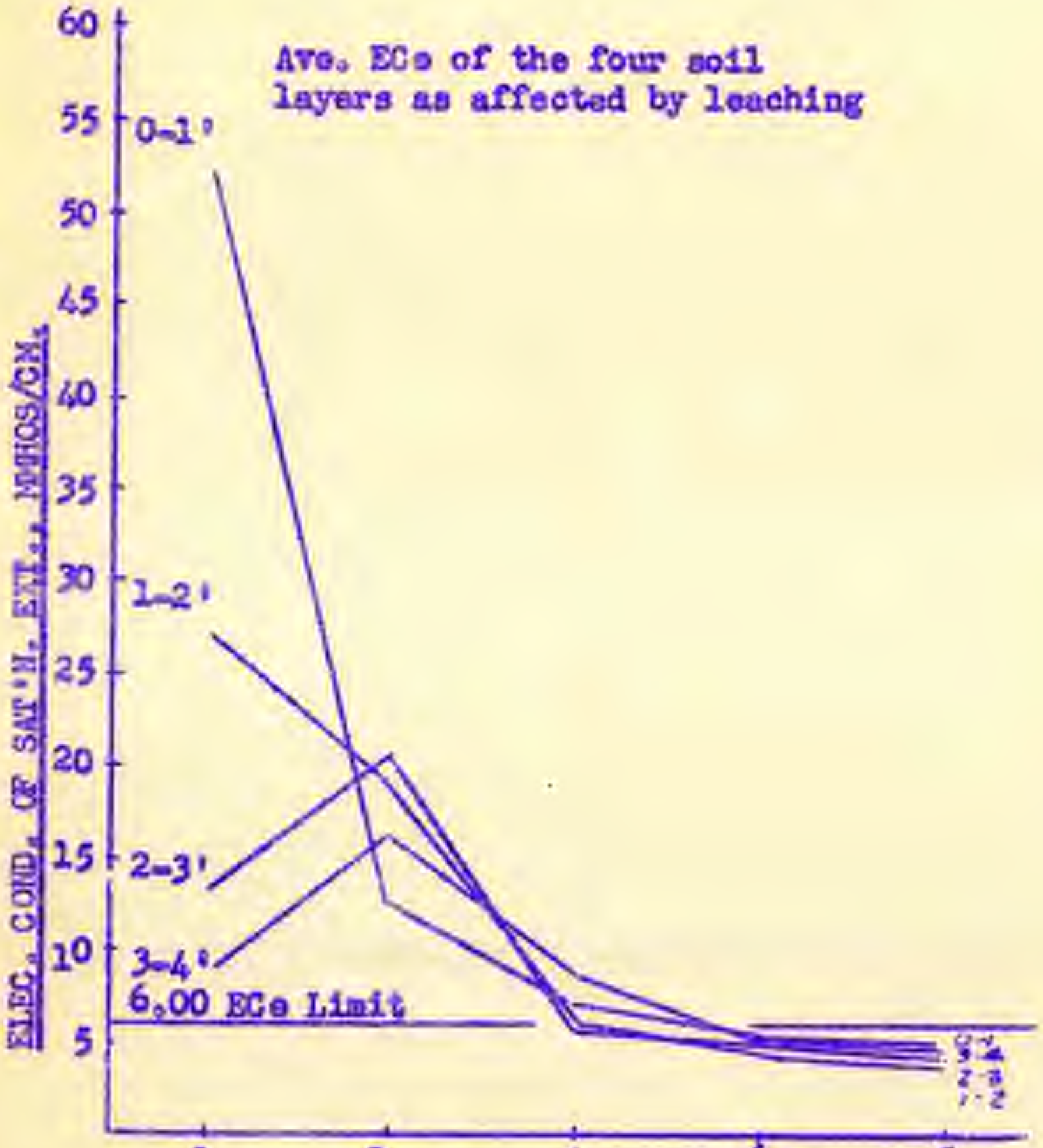
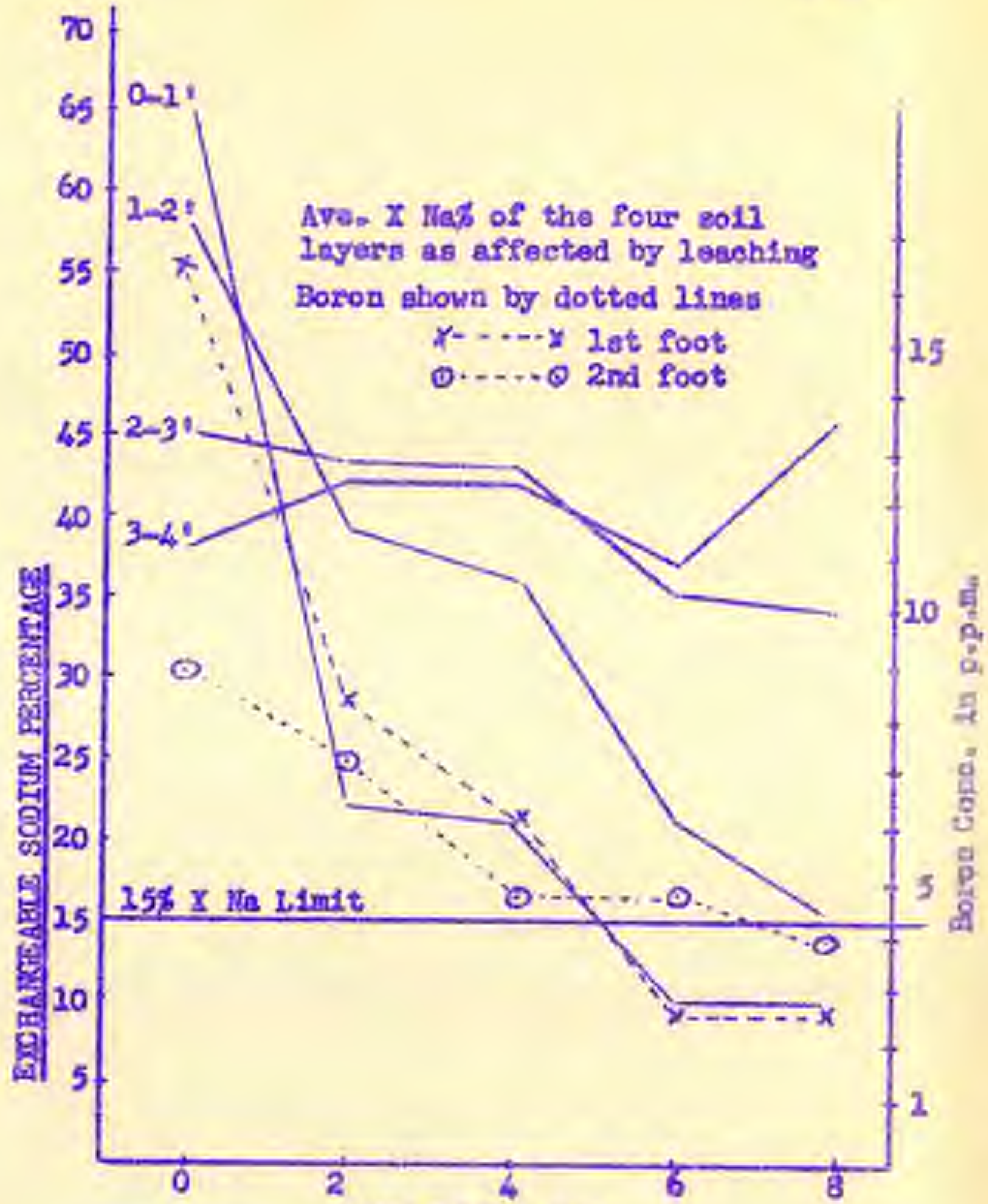


FIGURE 1. ACRE FEET WATER



ACRE FEET WATER

ICA RECLAMATION PLOTS AT FOA DEMONSTRATION FARM LASHKARI BAZAAR

Table 50 LABORATORY RESULTS OF COMPLETE LEACHING OF HIGHLY SALINE-ALKALI SOILS 7/31/57
(No other treatment used)

	Analysis of Samples before leaching. High	Average of 10 Samples	Low	Analysis of Samples after leach- with six and one-half feet of water* per one foot of soil. High	Average of 10 Samples	Low
Soil:						
Saturation Percentage	61.6	57.78	33.4	69.5	49.19	38.6
pH Paste	9.2	8.5	8.0	8.5	8.2	8.1
pH 1 ≠ 10	9.7	9.0	8.7	8.9	8.7	8.6
Texture	(Ranged from Silt Loam to Clay Loam, dominantly a Loam)					
% Salt						
Gypsum me 100/gms.	26.08	17.97	0	25.48	16.08	3.10
Saturation Extract:						
EC e x 10^3 @ 25° C (Millimhos/cm)	44.4	28.66	3.1	3.6	2.86	3.1
pH	8.6	8.4	8.2	8.4	7.9	7.7
Boron ppm						
Na me/l	600.0	399.70	10.0	17.5	11.34	8.0
Ca ≠ Mg me/l	48.4	32.37	24.2	32.8	26.13	1.9
Na me/100 gms.	32.5	22.01	10.0	.9	.5	.3
Exchangeable Na %:	69	61.8	48	10	4.0	2
Permeability Inches/Hour:						
First drop	45	20	8			
Initial	.76	.39	.12			
12 Hours	.75	.40	.10			
24 Hours						
Finish or 5 days	.74	.43	.10			

* Irrigation Classification of leaching water C4-S2.

(2) if watertable recedes, grow sweet clover, alfalfa, vetch, sesbania, guar or similar crops. The purpose of these crops is to provide organic matter for soil conditioning and to add nitrogen to the soil. If available, barnyard manures and chemical fertilizers should be used. The soil will be low in soluble nutrients following heavy leachings and the use of high phosphate fertilizers of fair to low nitrogen content will greatly stimulate the growth of green manure crops. Such crops should be turned under at lush growth to promote rapid decay and soil improvement.

2. Regular Cropping. Once the common field crops can be satisfactorily grown a regular rotation should be selected for the land. The crops which can be grown in South Afghanistan are arranged in the following table in order of their relative salt tolerance. The laboratory analyses for this project show the kinds and amounts of salts and alkali found. (Table 51)

In all cases it should be determined at what levels salinity, alkalinity and watertables can be reduced and maintained. If good drainage and complete removal of toxic saline-alkali conditions proves too difficult and costly a lesser degree of reclamation may be found desirable. In any case the crops selected should be those of the highest productivity and income value for the conditions to be maintained.

e.- Other Practices Used on Saline-Alkali Soils:

1. Other practices which may be useful, depending on the success of leaching and conditions of the soil, include:

a. Selection and growth of salt and water tolerant plants in accordance with the extent of reclamation achieved and maintainable. California Mariout barley which is adapted here has been shown to yield 80% even at 13-16 mho/cm conductivity provided germination was aided by keeping the ground moist and the salt concentration below 5000 ppm in the soil extract.

b. Seeding on moist soil and keeping soil moist until emergence (using light frequent wettings).

c. Using surface mulches of straw or manure to aid seedling emergence and prevent crusting.

d. Using cover crops to shade ground during emergence of fine seeds i.e., wheat with alfalfa.

e. Using large seeds that produce strong seedlings and emerge easily to plant with seeds which have difficulty in emerging.

f. Avoiding scalding plants by hot weather leaching.

2. Local Practices Used. The Afghans have learned by experience many ways to grow crops in saline-alkali soils although they show very little understanding of the use of subsurface drainage.

It is a common occurence to find farmers, who have some dependable source of water, raising crops of grain in the midst of extremely saline-alkali areas. One may find salts so high (3-8% immediately adjacent to an irrigation border that jeep wheels will sink several inches into the fluffy topsoil. Yet the laboratory tests on soils inside the wheat fields show normally no more than slight (.1-.2%, to moderate .2-.3%) salinity and comparable alkalinity. One finds also evidences of abandonment on a large scale. However, this may have been caused by a failure of water supply or other reasons as well as by water-logging and salinizing of the soil.

Their success in growing melons, squash, cucumbers, grapes and other crops adjacent to raised beds is illustrated in the sketch of salt movement (Chart LD 136). Careful location of the seed or cuttings avoids those zones where salts will accumulate. While this may not permit full cultivation of all the land and is not a permanent substitute for reclamation by leaching and drainage, it does point out that presently highly saline-alkali areas are not necessarily useless wasteland and may, when and if a dependable water supply is made available, be subjected to some use.

By the Helmand Valley soils and drainability surveys 5/6 of all saline-alkali lands have been found classed as not recommended for reclamation. About 1/6 were deferred for future reclamation the areas having been carefully selected for suitable subsoil permeability and substratum drainability. Such areas commonly occur interspersed with the presently irrigable lands.

The precaution was taken to provide a classification showing first, those lands that can be used now, and second, those lands that are suitable for use when reclaimed and show promise of feasible reclamation. Those lands which will be very difficult or slow to reclaim were placed in the general category of unsuitable lands along with definitely non-irrigable types such as gravelly or stony soils and sand dunes. Some of these lands are being farmed in small patches as described above. It is felt, however, that such lands do not justify consideration as project lands at this time and, unless population pressure becomes much greater than now, may never warrant expenditures of public funds for their reclamation and development.

As to the difficulty and costs of reclamation of the selected lands, careful differentiation must be made between an alkali soil, and saline to saline-alkali conditions found in the soils selected. The principal factors affecting reclamation as stated above are soil permeability and substratum drainability. As long as a soil in place transmits water (the U.S.D.A. Salinity Laboratory, says continuous transmittal of 0.04 inches/hr. will allow reclamation) vertically and laterally and excess water can be removed by drains, even seriously saline-alkali soils can be reclaimed. Whether special soil amendments are required to maintain permeability and keep the pH below toxic levels (generally below pH 8.7 in the saturation extract) depends a great deal on the methods used and the original gypsum and the lime content of the soil.

Soils classified as suitable for reclamation in Afghanistan generally have a basic water transmittal rate of over 0.1 inches per hour and have moderately fair or better subsurface drainage.

Table 6

8/12/57

A COMPARISON OF MONTHLY AVERAGE WIND VELOCITIES
AT GENERAL S. W. AFGHANISTAN LOCATIONS
(Miles Per Hour)

Stations -	Chakansur	Marja-Lashkarga Chah-i-Anjirs	Herat	Kandahar	Kabul	Ghazni
Elevations -	490 M.	790-765 M.	923	1000	1793	2241
Longitude -	62° 10' E	64° 15'-64° 20' E	62° 10' E	65° 40' E	69° 10' E	68° 20' E
Jan.	6.5	4.9	9.6	4.0	2.69	3.81
Feb.	8.0	5.3	8.1	4.2	3.36	6.27
March	8.5	5.7	8.7	4.5	3.52	5.60
April	7.5	8.5	8.5	5.0	3.02	8.29
May	8.5	5.8	8.1	4.0	3.09	7.39
June	12.0	6.5	11.6	4.5	3.81	6.05
July	15.0	4.0	14.8	5.5	4.59	6.50
Aug.	15.0	3.8	17.7	3.5	3.07	6.27
Sept.	10.0	3.7	11.6	2.5	3.29	5.60
Oct.	6.5	3.3	6.5	2.0	2.15	7.17
Nov.	4.5	3.6	6.3	2.0	1.70	5.82
Dec.	4.5	4.3	6.0	2.5	1.84	7.17
Avg.	8.9	5.0	9.8	3.7	3.1	6.33
	1/	2/	4/	3/	4/	4/

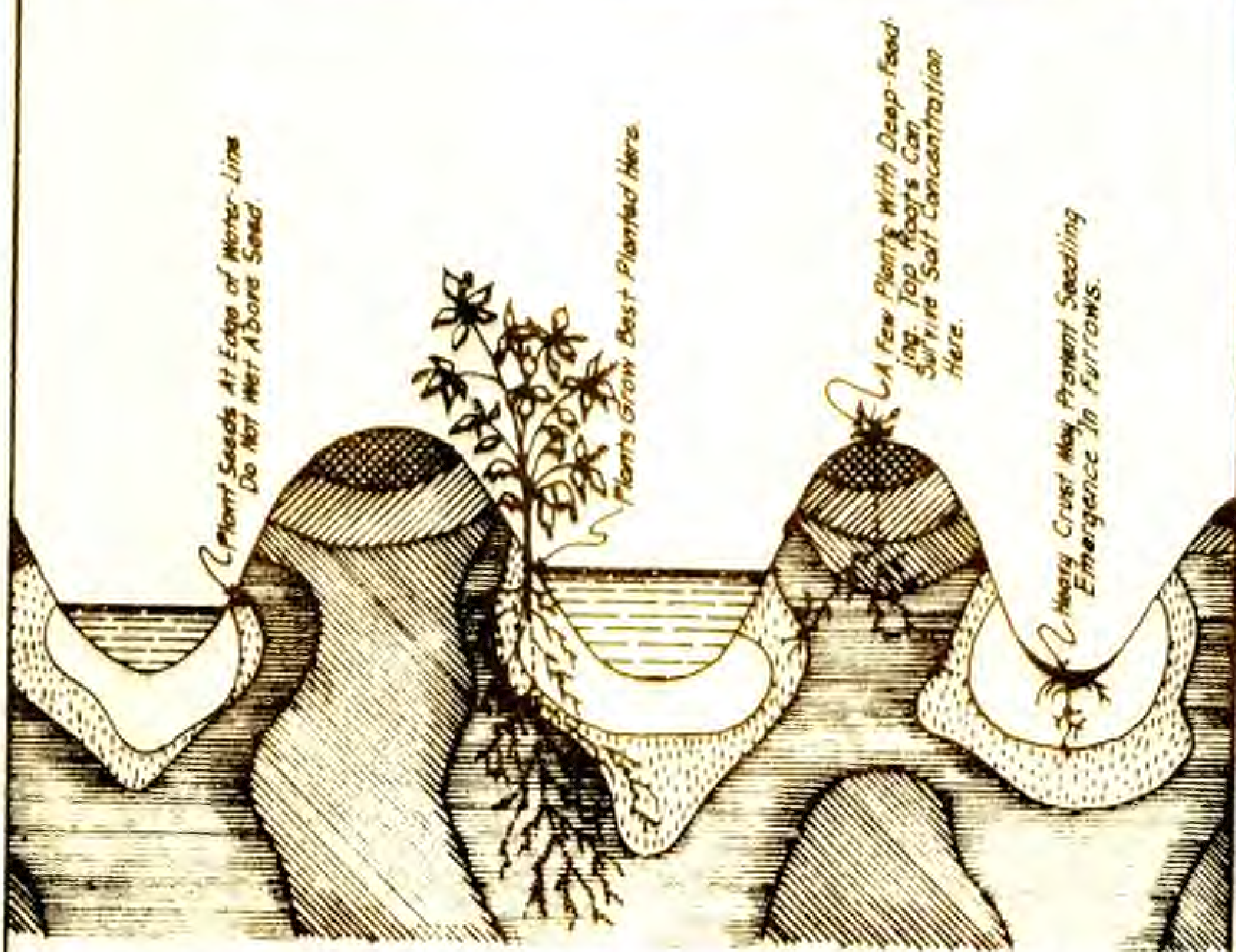
1/ McHuron Report 1904-'05, ICA - 1955-'56, MHA 1953.

2/ Data from Chah-I-Anjirs, Marja, Nad-i-Ali and Lashkarga, partial records 1951-'57.

3/ Afghan meteorological Service, Pakistan Consulate and unofficial estimates.

4/ All other records from Afghan Meteorological Service.

BED AND FURROW IRRIGATION OF SALINE SOILS



AN ILLUSTRATION OF SALT MOVEMENT IN IRRIGATED RIDGES & FURROWS

- Very High Salt $Ec \times 10^3$ = 50+ - No Plants Will Grow.
- High Salt $Ec \times 10^3$ = 15 - 50. A Few Highly Tolerant Plants Will Grow.
- Mod. High Salt $Ec \times 10^3$ = 8 - 15. Tolerant Plans Will Grow.
- Mod. Salt $Ec \times 10^3$ = 4 - 8. Most Common Crops Will Grow.
- Low Salt $Ec \times 10^3$ = 1 - 4. All But Most Sensitive Crops Do Well.
- Very Low Salt $Ec \times 10^3$ = < 1 . All Crops Will Grow Well.

In most cases these soils contain enough natural gypsum and lime to materially assist in reducing the exchangeable sodium percentage to safe levels.

These soils have shown by actual leaching trials that in most cases the salts, exchangeable sodium and boron can be satisfactorily reduced to where cropping can begin without adding sulfur, gypsum or other special amendments. Where one or more years of crops must be deferred or if low yields occur during the reclamation process, the government may provide some assistance in the form of subsidies or other incentives.

4. Wind Erosion Control. The possible effect of winds on water use by plants was discussed in Chapter II, and average wind velocities for several stations are given in Table 6. Wind velocities for the period, June-September, appear much higher in the Chakansur Area than in the desert and upper valley projects. Wind movement as a soil forming agency was discussed briefly in Chapter IV.

Wind erosion is a serious hazard in the development of certain parts of the Marja, Shamalan, Darweshan, Garmsel, and Chakansur Areas. Drifting sand on the ground surface produces small hummocks around desert shrubs and bunch grasses. Small dunes occur scattered over the surface of otherwise irrigated soils. Large active dunes and sparsely covered sand hills occur to the windward side of sites for structures in the central and lower Darweshan, So. Marja and So. Shamalan. The general direction of sand drift is S. E. in the Chakansur, east in the Garmsel and east to slightly N. E. in the upper Helmand Valley. Countering winds partially reverse and hold in check the general movement. Stretches of loose sands which occur on the windward side threaten the life and usefulness of structures. Considerable cleanout of deep drains on the Marja has been caused by drifting sands. On the east break of the Darweshan terrace are numerous patches of loose drifting sands and dunes to which the abrupt slope offers some obstruction and control.

The menace of drifting sand during periods of strong winds which are common to the lower areas is threefold: (1) filling of ditches and drains creating an annual high cleanout cost; (2) damage to young and growing crops by physical damage including a dessicating effect and smothering of plants; and (3) a source of discomfort and unhealthy living conditions for settlers and for other people working in the area.

Erosion control measures which may be required in these areas are of three general types: (1) temporary or emergency measures to be applied during the construction and land development phases; (2) permanent wind erosion control practices and measures; and (3) annual field control practices.

a. Temporary or Emergency Wind Erosion Control:

(1) Start land development on the windward side - If the general drift of sand is north eastward this would mean starting on the first block of land west and south of the sand drifts. This would protect the main outlet drain from drift and give protection to the next land block.

(2) Listing or deep plowing - Where suitable soils occur tracts to the windward of irrigable lands can be ridged in parallel high ridges and deep furrows normal to the prevailing direction of sand drift. Loose sands will catch in these barriers and be held against drifting until the furrows are nearly filled.

Ridges made 10-20 meters apart with a 2-foot moldboard or lister on a D-7 or D-8 will give a lot of protection to the area. Later if necessary another series of ridges could be made between these. This is an expensive procedure but may be required to facilitate land development and help in establishing protective shelter belts. Some tracts inside the projects may require similar treatment.

(3) Mulching of dunes - In places small dunes which are barren or only partially stabilized by small shrubs and grasses lie on or along-side tracts of irrigable land and are a hazard to land development. Where possible, the smaller ones should be spread out over the irrigable lands in the leveling process and plowed under with a large moldboard plow. Careful study of textural grades and depths is necessary to insure good usable land after plowing and smoothing. (See Figure 2 for deep plowing specifications). Deep plowing to turn under sands and bring up surface soil of finer texture has been profitable in trials made in the states and has achieved effective wind erosion control. Where impractical to level, these dunes may be temporarily stabilized by spreading straw or brush 2"-4" deep over the surface and anchoring it by packing with a sheeps-foot roller. Seeding of sand stabilizing grasses and forbs should be made in the mulch just ahead of the winter rains. Where practical, plantings of shrubs, grasses and trees should be made on the windward side of active dunes early in project development.

b. Permanent or Long-Time Wind Erosion Control Measures:

(1) Range Control - Observation of range cover in the lower Helmand and Chakansur Areas show a number of grasses and shrubs capable of growing on deep sands or on sandy soils. Eight species of grass, 5 different shrubs and several annual and perennial forbs were found on a single field trip over sand areas in the Chakansur, near Yakchal, in the Shamalan and in the West Marja areas. Complete restriction of grazing or use for fuel in these areas would allow the plants to re-seed and allow the maximum accumulation of vegetative growth for wind erosion control. Artificial seeding and planting of indigenous shrubs and grasses should be undertaken on the more barren areas. Other sand stabilizing plants could be brought in and increased by seeding and transplanting methods. Complete restriction of grazing and harvesting for fuel, and a system of range improvement will probably be the most economical and beneficial of any control measures which can be devised for protection of irrigated lands from sand encroachment. Areas of sufficient size should be declared public domain, and grazing and fuel harvesting prohibited until control of drifting sands could be established. Strict regulation would be necessary afterwards to prevent deterioration of the protective cover.

(2) Tree Windbreaks or Shelter Belts: - Essential to control of drifting soil and to protection of growing crops from hot winds as well as sands is a complete system of windbreak tree and shrub plantings throughout each project and on its windward perimeter. Russel K. Smith, FOA Forester, studied species adapted to the area and made recommendations which were included in the Supplementary Project "Afforestation Program", September 6, 1953, and in his "Report on Afforestation in Helmand Valley", October, 1953. C. W. Corson gave an extensive list of usable species in his August, 1956 Report on the Forestation Program (ICA). In these reports a number of adapted species were recommended from which various planting combinations can be made. In addition the numerous local shrubs which appear to grow on sands under natural environment should be selected and used in windbelts for checking and holding sands.

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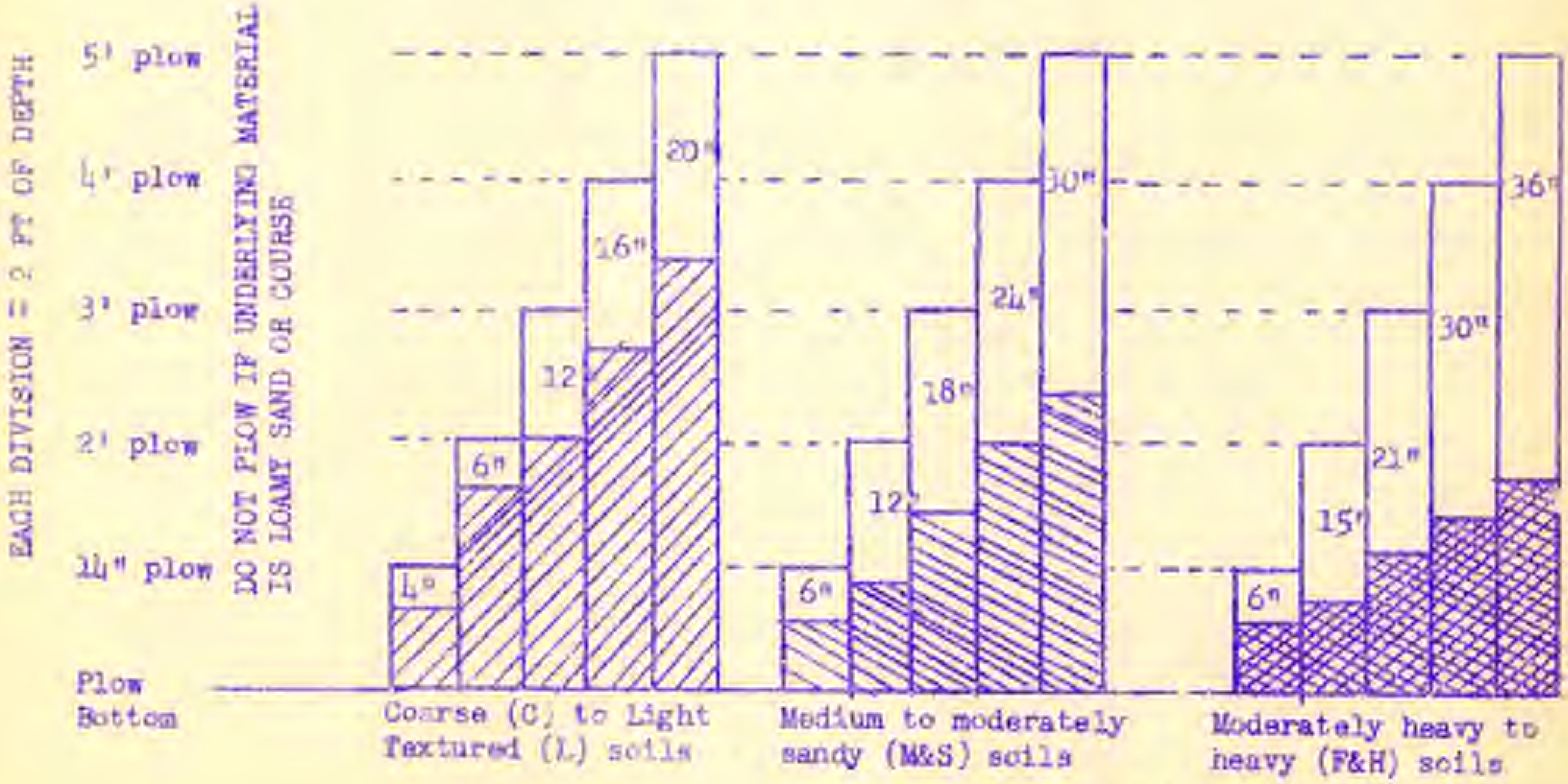
(PRACTICE S-5) SPECIFICATIONS FOR TURNING UNDER SAND DEPOSITS
(ACP-S.C.S. SPECIFICATIONS - FLOOD RECLAMATION, 1951-1952)
(DEPOSITS MUST BE COARSER THAN FINE SAND. AT LEAST 8" OF OLD SOIL, FINER THAN FINE SAND, MUST BE PLACED ON TOP BY PLOWING)

Figure 1. Minimum Plowing depths in Inches.

	Texture of Underlying Soil	DEPTH OF SAND COVERING IN INCHES												
		4"	6"	9"	12"	15"	18"	21"	24"	27"	30"	33	36	39
:1¼	Heavy (H)	12*	14**	17**	20	24	28	32	36	40	48	56	64	–
	Moderately Heavy (F)	12	14	17	22	27	32	36	40	48	54	60	–	–
:1	Medium (M)	12	14	18	24	30	36	42	48	54	60	–	–	–
	Moderately Light (S)	12	14	21	28	35	42	49	60	–	–	–	–	–
:3	Light (L)*	12	18	27	36	45	54	63	–	–	–	–	–	–

Coarse (C)* *Plowing less than 12" deep not recommended; nor is plowing recommended where texture of underlying soil is coarser than loamy fine sand.
**At least 8" of old soil must be turned to provide adequate thickness of soil for a seedbed and for tillage operations.

Figure 2. Maximum practical depths in inches of sand plowable by moldboard type plows of designated size.



Prepared by: Claude L. Fly - State Soil Scientist
Soil Conversation Service
12/14/51

The type of plantings which can be made include:

(a) Woodlands. Areas of Class IV and V lands would afford woodland areas of some use. The recent alluvial soils could be adapted to this purpose. Woodlot plantings such as recommended by Russel K. Smith should be used.

(b) Perimeter Windbelts are needed on the windward side of large areas. If strips 70 to 100 meters wide could be utilized, several shelter belt strips with intervening spaces would serve to afford protection of irrigated lands.

(c) Sand Dune Stabilization Plantings of local shrubs and grasses found to do well on the sands should be planted on and around dunes which are so large as to be uneconomical to level and plow under. Where farm ditch and border waste water can be used, plantings of trees and shrubs around the margins of dunes will help to check drifting and allow local grasses and shrubs to establish themselves on the edges of the sand ridges. The hay method of seeding grasses should be used; i.e., hay cut at maturity of seed should be spread over the dunes and packed with a sheeps-foot roller as described above. A layer of mulch (hay, straw and brush) 2"-4" thick will, when so packed, effectively holdsthe sand in place until seedlings have a chance to establish themselves. Every effort should be made to procure seeds and seed hay of sand grasses during a season when they have made abundant and viable seed production. Seed plots and cuttings from sand-adapted shrubs should be started so as to provide planting materials needed for January to March plantings. Protection of these areas from grazing and fuel harvesting is essential to establishing and maintaining protective cover, and preventing the danger that the sands may become unstable and start drifting into irrigation and drainage ditches and into fields where they will seriously interfere with cultivation and may smother or kill growing crops.

(d) Project Shelter Belts of 3 to 5 rows of trees and shrubs should be planted in areas subject to high winds in hot summer months, to the west of north-south laterals and sublaterals and to the south or north (Chakansur) of east-west laterals and sublaterals. This will give growing crops protection from the westerly and southwesterly winds which are most damaging in the area. Five-row belts are preferred along main lines while two and three-row belts may be used elsewhere. Spacing under irrigation may be in rows 2 meters apart with trees planted 2 meters and shrubs 1 meter apart in the rows. Plantings should be staggered between rows so as to present a solid front toward the winds. All plantings should be at least 5 irrigation borders (120') windward of the irrigation ditch or deep drain protected so that sand drifts passing through the belt may not drop directly into the ditch but can be disposed of by leveling and deep plowing or other means. All plantings must be planned and laid out so as to least interfere with project irrigation and drainage structures, particularly with tile drains.

(e) Individual farm plantings may be needed to give complete protection. The plantings may afford protection at farm intervals of 220, 440, 660, or 880 feet with the closer spacings being on the sandier, more erosive soils. The distance between wind barriers may be further shortened by single rows of trees on farm boundaries in a north-south or east-west direction. Low-growing fruit or nut trees or a combination of shrubs and intermediate trees could be used.

As projects become older and permanent orchards, vineyards and village plantings become well established changes in spacing of tree belts by elimination of some of the closer spaced tree rows may be made. In many places there

is a large proportion of Class V lands around and in a project area. These lands should be utilized as much as possible for windbreak plantings and for fuel production. In places it will be necessary to use lands of irrigable classes to insure satisfactory tree belts in the proper locations. If a water table develops, the tree rows may draw a considerable portion of their water requirement from farm irrigation and ditch percolation losses rather than from direct irrigation. Such transpiration may in turn help to lower the water table.

c. Annual or Farm Wind Erosion Control Practices:

Annual or farm wind erosion control practices should be scrupulously adhered to as wind erosion can do considerable damage in a short time. One uncontrolled field can quickly block a main lateral with sand and cause damage to crops below this point by cutting off the water supply. Drifting sand smothers, desicates and physically damages young plants. Since irrigation water will be available at all seasons of the year, a few simple and easy to follow practices will affect control of wind erosion. These should be taught and demonstrated early in the settlement program and every effort made to see that they are followed.

(1) Maintain a vegetative cover at all times except when preparing the land and seeding another crop. Complete removal of wheat stubble as practiced in Afghanistan will be dangerous on sandy soils unless followed immediately by seeding of a cover crop of some sort. Preferably, the new crop should be seeded in the stubble of the harvested crop so as to give some protection to seedlings. This means both summer and winter crops should be grown.

(2) Plow so as to leave the surface rough and cloddy to check the soil from blowing until ready to seed. The clods will slake easily on wetting and the seed bed can be harrowed as seed are broadcast.

(3) Add organic matter to the soil through use of green manure crops, stubble and animal manures. A legume used as a green manure crop at frequent intervals will help assure good crop yields.

(4) Plant tender plants which are easily damaged by wind and sand in single borders between borders of taller growing, more resistant plants. Thus a border of maturing wheat may protect an adjacent spring crop or several rows of sorghum may protect an adjacent border of late summer or fall planted crops.

(5) Make protection plantings of tall resistant plants in single or double rows to further protect tender plants if needed.

(6) If wind erosion starts, the blowing area should immediately be plowed dry to form clods, or watered and then harrowed or plowed while still moist. In no case should blowing be allowed to reach a stage where shifting hummocks are formed as these will fill canals and windbreaks and are difficult to check.

5. Control of Vegetation in the Main Canals and Drains. Growth of vegetation along the banks and in the canal will, if uncontrolled (1) retard the normal velocities and decrease canal capacity to deliver water, (2) cause silt and clay deposition, resulting in decreased capacity and in channels of uneven flow which may damage canal banks, (3) clog turnouts, checkgates and other structures, (4) make bank inspection and maintenance difficult, and (5) reduce the effectiveness of drains.

a. Control of vegetation falls into two categories according to type. Bank growth, such as tules, cattails, bamboo, willows and tamarisk, can be controlled by:

(1) Cutting or Mowing: The best time to remove the entire plants including the root crown and rhizomes would be in the winter months when the canal is dried up for maintenance repairs. Once this has been done, vigilant patrol of the banks should be maintained during the growing season and the young plants cut off or removed before they have had a chance to develop a strong root system.

(2) Burning: Mobile weed burners such as used on a stateside "railroad right-of-way" can be devised with a long flexible flame nozzle to extend down to the water surface. Weeds which have most of their growth above the surface can be kept under effective control by this method.

(3) Spraying with selective weed poisons: Where no livestock are allowed to browse on the poisoned plants, the use of chemical sprays may be practical. Quite a number of selective sprays have been developed. Selection will depend on the plants to be controlled and upon the mechanics and cost of use. Data is obtainable from the states on the developments in weed control by chemicals.

b. The control of pond weeds is more difficult. These root and grow within the canal and have most of their vegetation in and below the surface of the water. Three principal methods of control are in use:

(1) Mechanical Removal: Draglines may be used equipped with suitable excavators having teeth to break loose and drag out the weed growth; two tractors may be used to drag a heavy chain along the bottom of the canal and break loose the floating-type weeds. These would be washed down to checks or other structures and be raked out of the canal or may be flushed out through wasteways. A scraper shaped to the canal bottom section can be constructed for the same type of operation and would serve to cut loose the roots as well. Drainage ditches can be cleaned by this method.

(2) Chemicals or Weed Poisons: Aquatic plants are more susceptible to some chemicals such as napthas and "Benechlor", than are land plants. When these chemicals are emulsified in ditch-water, aquatic plants are killed. The great danger lies in use of the water by people and livestock. There is also some danger to field crops if the water is diverted immediately for irrigation. Rapid progress is being made in development of selective chemicals so that a safe control may be in the offing. The latest information on chemical control of aquatics should be obtained and be made available.

(3) Periodic Drying and Burning: When opportunity permits, the canal should be completely emptied and the bed allowed to dry. Repairs and cleanout can be made at the same time. When the weed growth is dry, it can be raked and removed or burned. The burning will help to destroy seeds, spores and rhizomotous roots. The best times for this work on the main canal would be in January when no water is needed for irrigation and immediately after the last wheat irrigation (approximately May 15) before the heavy demand for summer crops begins. Only two or three days of hot sunshine would be required to dry out the water plants at this time of year.

There is no one method that is cheap and infallible. Weed control is a constant expense that must be reckoned with in ditch operation and maintenance. For the Boghra it would appear that, after the initial cleanout, the combined use of hand labor to control ditch bank weeds and periodic drying and burning to control

aquatic weeds would prove feasible and economical. The initial cleanout of the worst sections prior to major water demands in the Marja and Shamalan may require use of dragline or other heavy equipment in the upper reaches of the Boghra.

6. Flood Control. Severe damage occurred to fields, bridges, canals and outlet drains along the bottom lands of the Helmand River in May and June, 1957. In Chapter III, Water Resources, it is pointed out that such floods may occur every three to 5 years. Had it not been for the effect of the Kajakai dam the damages would have been much greater.

The only flood control device of any real value to the Helmand Valley development is the Kajakai dam and reservoir. Unfortunately the full value of this structure for flood control has not been utilized. From data given on inflow in Table 25, Chapter III, it can be seen that 75% of the total flow of the Helmand comes down in 4 months or 2.7 times the present active storage capacity. If the reservoir was almost empty at the beginning of March and the gate valves held wide open (8,500 cusecs) for the next three months, the reservoir would fill and spill 300,000 acre-feet on the average. Since the remainder of the year would yield another 867,000 acre-feet the total of 2,267,000 would be 4 times the present use demand. It is not necessary that waters be held in the reservoir prior to the annual high flow. Even the lowest runoff year on record would fill the reservoir to 90% of capacity in the four months of March to June. Damages to structures along the river can be greatly reduced by taking every advantage of the storage capacity of this large reservoir without in the least affecting the late summer irrigation requirements down stream.

Additional storage and controls would be needed downstream if the Chakansur area is protected from annual flooding. As pointed out in Chart LD 134 Chapter III, about 4,000,000 acre-feet annually can be expected to enter the basins each year. The following chart is extracted from the Chakansur Report to show the accumulative flood volume expectancy from all rivers emptying into the Chakansur Basin and the accumulative effect of various storage and flood control devices up to the maximum that could be provided by any practical means. A flood of 150 year frequency would exceed the maximum protection indicated.(Chart LD-175).

Protection for such river valley irrigation structures as the Shamalan Canal are needed but will be subject to frequent damage and possible destruction unless the reservoir is so operated as to utilize its major capacity for reducing the high flow peaks which are of rather frequent occurence.

CHAPTER VI

WATER REQUIREMENTS AND FERTILITY MANAGEMENT

1. Crops

It was pointed out in the discussion of climate, Chapter II, that a la variety of crops can be grown in southwest Afghanistan. Growing seasons r from 250 - 300 days. Freezing temperatures seldom last more than a few h temperatures below 20°F. are relatively infrequent. No 24-hour perio occurred at Kandahar. Common fruit trees will stand temperatures recent publication stated that the following species would stand temperature without injury of Pecan: 9°F., carob: 15°F., Japanes olive: 15°F., sour orange: 18°F., date palm: 15°F.

Table 16 shows that on a tonnage basis the present annual consum products is wheat: 45.20%, corn: 21.25%, vegetables: 19.10%, fruits, products: 8.45%, and all others: 0.20%. Thus grains constitute products consumed.

Table 18 estimates that of the land in crops the distribution is: orchards: 4.6%, vineyards: 13.1%, wheat: 63.1%, alfalfa: 5%, vegetables: 6.5%, corn: 5.0%, and all other crops: 2.9%. The extremely high percentage in grain crops, particularly wheat, correlates with the high grain diet. Considerable fruit is exported. Animals are raised chiefly on desert range, so the acreage figures do not necessarily correlate with consumption.

A traffic survey conducted October 16, 1952 to October 15, 1953, indicated that exports moving through Kandahar to Chaman consisted of fruits: 76% (tonnage basis), cotton: 11%, wool and skins: 12%, anise: 0.48%, others: 0.52%. The total tonnage was 56,860 and the dollar value at 42.534:1 was estimated at $7,000,000, or $125.00 per ton.

The Helmand Valley Development Program July, 1953 suggested a shift toward the higher value cash crops, such as fruits and nuts: 16%; cotton, sugar beets, oil seed crops and other fiber crops: 17%; with 23% in legumes, hay and pasture. By growing a greater amount of legumes, soil fertility could be improved and yields increased. More animal products would be available for sale and manures could be returned to the soil. Less land would be required for wheat as the yields would be boosted.

In setting up land settlement programs among the farmer applicants HVA has suggested the following:

Class I - 15 jiribs (7.5 acres): alfalfa 2, corn 6, cotton 4, garden and house 1, vineyard 2.

Class II - 20 jiribs (10 acres): alfalfa 2-5, corn 6 or cotton 4, wheat 5-10, garden and house 1, vineyard 1-2.

These high winds referred to by local people as the "Bad uz Yak Sad-o-bist Roz" sweep across the great basin almost continuously from 343°-316°. Vast areas of the basins and nearby lake benches and deserts are severely eroded. Over 200,000 acres of marching dunes have accumulated in the southeast part of the basin and are marching southeast and eastward paralleling the general course of the Helmand River. Winds reported at Herat appear to be a part of this general pattern. Data from the more easterly deserts and the higher valleys do not show these high summer winds, however.

By means of the Meyer formula; which includes the wind velocity factor, the computed evaporation is compared in Table 7, with data from open pans. It is noted than in the two areas where the high summer winds are not so noticeable the measured and computed evaporation compare fairly well. The Chakansur data shows computed evaporation to be 115% of measured evaporation. To determine what effect the use of differences in wind velocities and actual or computed evaporation might have on estimates of water consumption a comparison of these methods is made in Table 8. Here three approaches are compared. Basically, the study of Arghandab-Tarnak water allocations 3/, which has been reviewed by a number of competent irrigation engineers and water use authorities serves as a basis of comparison. The Blaney-Criddle formula was used for this analysis and report. Using the same crop rotations and percentages of the areas in various crops a comparison is made of the water requirements for the central Helmand Valley represented by Marja, Nad-i-Ali, Shamalan and Seraj projects and the lower Helmand Valley represented by the Chakansur, Garmsel and lower Darweshan projects. The Darweshan is shown separately. The first comparison assumes that the water use requirements of the other desert projects are proportional to the measured evaporation at Kandahar and at the projects studied. Computed to diversion requirements per acre at 55% farm irrigation efficiency and 75% delivery efficiency with 5% return flow usage, this comparison gives as diversion requirements Kandahar-4.3 acre-feet, central Helmand projects-5.3 acre-feet, Chakansur-7.7 acre-feet. Using the calculated evaporation, (Meyer formula) which involves consideration of differences in wind velocities, gives as diversion requirements Kandahar-4.45 acre-feet, Marja-5.45 acre-feet, Darweshan-7.00 acre-feet, and Chakansur-9.4 acre-feet. The increase in computed requirements are not significantly great except in the Darweshan and Chakansur areas. The Blaney-Criddle Method which considers generally the relation of mean monthly temperature and sunshine hours gives:Kandahar-4.3 feet, Marja-4.8 feet, Darweshan-4.9 feet and Chakansur-5.2 feet. These values differ significantly in the Darweshan and Chakansur areas from the above values which considered the high summer winds and high evaporation rates. In Chapter VII these differences in climatic characteristics are given consideration in water requirement studies.

e. Growing Season and Range of Crop Adaptation -

Kandahar has an average of 264 frost free days with a recorded range of 245 to 285 days with no temperatures below 32° F. No single 24-hour day of record has been below 32° for the full 24 hours. Generally these low temperatures last only a few hours and the days are in the 40-60 degree range. The average daily maximum ranges from 44°-67° for January and 48°-73° for December, the coldest months. The average daily minimum ranged from 22°-48° in January and 21°-47° in December. The lowest temperature recorded was 12° and the highest 112°. January averaged 17 days and December 15 days when the temperatures reached 32° or less.

3/ Water allocations Study of Arghandab-Tarnak Area - MKA July 1956, supplemented June 1957

Class III - 25 jiribs (12.5 acres): 5 alfalfa, 4 cotton, 4-6 corn, 8-10 whea garden and house 1, vineyard 1-2.

Class IV - 30 jiribs (15 acres): 5 alfalfa, 20 wheat, 3 corn, 2 garden an house.

This sort of program would still overstress grain production. It would allow fruits and vegetables for an average family but would provide three ti the grain necessary for a well-balanced diet. More land should be donated soil-building legume crops for improving crop yields. Less land need be d to low value grain products and more to products offering higher econo such as fresh and dried fruits, nuts, fiber and oil seed crops and sugar

The ratio of acreages allowed for farms of different land classes reflect the potential productivity of these lands but is an arbitrar by Afghan authorities. When the lands have been fully developed and (see Stage 3 of Physical Stages of Soil Development, Chapter VIII) th duction values for Classes I - IV, using the above acreages in crops good farm management in the ratio: - I = 1.00, II = 0.955, III = 0.812 For equal gross production values then, the farm sizes should be nearer I = II = 21 jiribs, III = 31 jiribs and IV = 49 jiribs. It has been pointed out in previous studies that these low acreages may barely sustain a family in the early stages of development or even fail to do so. Even after full development the incentive for doing an efficient job of farming may be stifled by overcrowding on small acreages. Public revenue accrued through taxation of marketable farm surplusses is needed for retirement of public indebtedness for the overall development. Much good can come through a study of ways and means to raise more per family than the family can consume and to find suitable markets.

Several crops which may be introduced or expanded in S.W. Afghanistan are the following types:

A. Fiber Crops - Cotton, hemp, flax, ramie, and silk. Silk culture while an old and established enterprise in Asia, has received new impetus in this country through efforts of the U. N. - F.A.O. experiments at Baghlan. Some notes on this crop as furnished by the F.A.O. expert follow:

Sericulture - A new money crop for Afghanistan

1. Graft onto native mulberry stock a non-fruiting Japanese variety of mulberry which produces leaves relished by silkworms. (This has been done on some 40,000-60,000 trees in Baghlan. Nearly two million mulberry seedlings growing to be grafted.)

2. Introduce high silk-producing strains of silkworm. (Silkworms from eggs brought in are now producing silk at Baghlan.)

3. Prepare land by growing a green manure crop of legumes, turning it under and thoroughly discing the soil ahead of planting trees.

4. Plant trees 1 meter apart in row 3 meters apart so that inter-tilling can be done. This spacing can be varied to grow 1250-2000 trees per acre.

5. Grow winter vetch or clovers between tree rows and turn under as green manure, a regular practice in sericulture.

6. Properly irrigate and use commercial fertilizers. This will greatly increase leaf yields.

7. Results of some tests at Baghland showed that a yield of 14,400 lbs. le produced, 720 kilos of cocoons (100 seers) valued at 180 Afs./seer or 18,000 A Acre or $423.20 at 42.543 Afs. = $1.00.

b. Fruit Crops - dates, citrus, olives, figs. The production of suitabl and packed fruits for export could be an increased source of income even th several million dollars' worth of fruits are exported annually now. Conside care should be taken in selecting base stock for citrus and olive plantin more winterhardy types will be needed. Native olives are growing in the provinces. Some of these could well serve as a root stock for gr ting types. The country needs other sources of edible oils and fats t (roghan-i-gosphand).

c. Oil seed crops - olive (above), cotton (seed for oil and prot bean (oil, edible food, animal food, numerous commercial products) oil, soil building crop), castor beans (medical, lubricating and i sesame, and others.

d. Nut Crops - Pecan, walnut, pistachio, almond.

e. Hay and Pasture Crops - Many kinds of legumes and grasses can be grown. These need to be increased considerably, not for livestock production so much as to provide organic matter, build soil structure and add nitrogen to the soil. The practice of removing all vegetation from the land is common here. The soils have become so low in nitrogen, organic matter and readily available phosphorous that crop yields have reached a low level. Turning under a green legume crop has quadrupled grain yields on some soils in the Nad-i-Ali area. Because commercial fertilizers are not available here, it is even more urgent that legumes be grown for soil building. The lack of fuel forces the burning of animal dung, thus destroying one of the most valuable soil builders available. Many soils, especially of Class IV lands, are better suited to livestock production rather than to cash grains. Legumes and grasses which can produce fair returns on wet, saline soils are needed in many places.

In general every cash crop should follow a green manure crop unless commercial fertilizers and animal manures are used. The mild winters make it possible to grow winter legumes such as vetches or winter peas, following a summer crop. The growth can be pastured some during winter and early spring and turned under for green manure a few weeks before the next summer crop is planted. Longer-growing deep-rooted legumes such as alfalfa, along with deep-rooted grasses, should be grown in the Rotation as often as practical.

2. Water Requirements of Crops.

a. Plant Growth Habits Affecting Water Use - Plants vary ~~in~~ their growth habits and in the use of water for growth. Irrigation is concerned with supplying water to each crop in a manner calculated to control its growth and production habits for greatest economic returns. For instance, if forage is desired, water application may be liberal and frequent; if seed production is desired, a stress period may be introduced. Some plants if watered too heavily at fruiting time may produce

extra vegetative growth rather than set and mature fruit. Grapes and pomegranat watered too liberally during ripening period may burst and spoil.

(1) Root distribution and moisture use.

Many plants draw most of their water from the 6"-18" layer of soil. O as deep-rooted trees may feed to several feet. Walnuts have been reported the soil moisture to near the wilting coefficient up to 12 feet before sh injury.

Table 52 shows graphically the rooting habits of various types of this graph crops may be selected for adaptation to different effectiv Most crops do best on deep, well-drained soils, but many are capable to a wide range of soils depths and textures. Grapes, as illustrate were found at Indio, California to draw 66% of their moisture from feet, 29% from the next three feet, and 5% from 6-9 feet or lower. with a water table at 1 meter have been observed in several Afghar Mesquite and athol roots have been known to penetrate 30-40 feet i Alfalfa is a deep-rooted crop feeding 6-8 feet or deeper. Where h or hardpan exist, it has been observed to produce fair yields wit root system.

In Table 52 the normal rooting habit in a deep, wel The irrigation water requirements for each crop are ca the rooting habit is more restrictive than soil depth.

(2) Planting and cultural methods may affect wat

The consumptive use requirements of several types gation requirements at selected levels of irrigation ef the study of Arghandab-Tarnak water allocations, July, must be kept in mind in evaluating water requirements. October through January so that a portion of the land a portion will be planted after winter rains and wil As little as 8" of irrigation water has been used in ranges from 14"-18".

Cotton, orchard and vineyard lands may be giver early spring irrigation to completely fill the root rapid growth begins in May. The deciduous fruits pears, peaches, pomegranates, figs, plums and necta are spaced too closely and are never pruned. Excess expansion of orchards should be along lines of good including economic use of water.

Vineyards present a different situation. The trenches 1-1½ meters deep which are 8-12 feet apart. meters apart in the rows. The excavated soil is th strip to make a large ridge and the vines are trai using it as support. Irrigation is done by watering Inquiry among many farmers indicated 8-12 waterings of as a common practice. About 18"-24" total water was ap

In setting up water requirements it is assumed that surface plantings may eventually be used on part of the land and a normal consumptive use for this system was included. Research studies show that deciduous fruits and vineyards can be stressed heavily following harvest of fruit without serious damage to the tree or vine. This principle is used to conserve water in late summer and fall when water supplies are low.

(3) The effect of reducing water supplies on yields.

It is well known that for most crops the increment of yield obtained for an added increment of water above that necessary for bare survival is greatest for the first increments added. There is a variable decrease in increment of yield per added increment of water as maximum yields are approached and, for many crops a decrease in yields if the optimum is exceeded. This latter often results from a combination of causes such as waterlogging the soil, diseases and insects, and vegetative regrowth. Certain legume and hay crops such as alfalfa show relatively the same increase in yields up to several feet of water, while wheat shows rapidly decreasing ratio of yield for water applied from 1½ to 2 feet of water and rapid decline in yields when over 2 feet are applied. Drawing LD 140 illustrates these relationships for several common crops including heavy water users such as cotton, alfalfa and fruits. In the case of Acala cotton 80% of full water application gave 95% of full yield, 66%-89% and 50%-74%, respectively. Reductions in yields caused by a 20% reduction in optimum water supply are shown in chart as: Cotton = 5%, Wheat = 5%, Milo = 4%, Fruit = 12.5%, and Alfalfa = 15%, respectively. This presumes timely and efficient use of the water received. Over the period of record less than 30% of the years would appear to have low supply from the Arghandab inflow. Helmand flow is more than ample for all lands now suitable for use.

b. Cropping Practices for Efficient Water Use.

Arizona, California and New Mexico irrigation research on the basic crops have established sound working principles by which irrigation schedules for each crop can be maintained. Briefly, irrigation should be designed, where water supplies are ample, to maintain the plant at seasonal growth rates consistent with maximum yields whether it be of fruit, grain or forage. This should be done with a minimum of wastage through percolation and runoff. Where water supplies may be lacking, applications of stress at the least critical times is necessary so that reduced moisture supplies will result in the least reduction in crop yields. On normal soils when field crops have reduced the moisture to near wilting percentages in the upper 1/4 of the root zone there are increasing amounts of unused water in the successively deeper portions of the root zone. In soils with variable textures and depths, layers other than the top 1/4 of the root zone may be depleted first. Maximum growth results from refilling the plant root zone to near field capacity each time before the limiting layer reaches the wilting point for the crop being grown. In this manner no portion of the roots feeding water and nutrients to the plant are damaged by drying out. In actual practice with variable water supplies it is not always possible to attain such ideal conditions.

Following are some of the practices found useful for some common crops.

(1) Cotton: - California Method.

(a) Pre-irrigate in late March or early April (as soon as water supply is known) to depth of 5 feet, if in deep soils, or to known effective soil depth if less than a 5-foot root zone.

(b) Plant without further irrigation on sides of lister ridges between April 10th and May 1.

(c) Stress 6-8 weeks or until squares start to form unless, on medium depth or saline soils, another irrigation is necessary to prevent permanent wilting.

(d) Irrigate during fruiting period so squares form along lateral branches about 4" apart and no blossoms appear in top branches until late - this may require irrigation every 3-6 weeks during July and August. In critically hot periods, light irrigations every 7 days may be needed for cooling effect.

(e) Reduce irrigations after full boll formation and discontinue after about September 15.

(2) Arizona Method.

Steps (a) and (b) are the same.

(c) Keep ground fairly moist (near 50% of waterholding capacity to July 31, or until squares start to form.

(d) Reduce watering during fruiting but not enough to throw squares.

(e) Irrigate as in step (e) above.

(3) Variations for different water years (pre-irrigate in all cases).

(a) Planting April 15-May 5.

(b) 1st Irrigation: Wet year June 15-July 5; normal year July 1-15, dry year July 15-25.

(c) Second Irrigation: 3 to 6 weeks later.

(d) Later Irrigations: Wet years 2/2-weeks apart and 2/3-weeks apart; normal years 2/2-weeks apart and no more unless serious wilting occurs; dry years - 1 July irrigation and 1 August may suffice or irrigate during fruiting period only.

(4) Grapes

(a) Pre-irrigate during dormant season or very early growing season to fill root zone.

(b) Stress early growth until upper root zone is nearly dry.

(c) Irrigate from then to early blossom time until fruit is well filled but not ripe. Keep root zone well above wilting point.

(d) Do not irrigate or irrigate only lightly during ripening and until fruit is harvested.

(e) After harvest, early grapes may need one or more irrigations to prevent loss of all leaves before frost. Grapes may be stressed heavily after harvest without harm to the plant.

Present vineyard irrigation practices vary widely depending on water supply. Some irrigate every month of the year as follows: 1-6" irrigation each cool month, then 2-6" irrigations each warm month, and 3-6" irrigations each hot month. Some irrigate only once in the winter months and twice in the fall months. Since the custom of planting grapes in deep trenches is variable in depth and spacing, it is difficult to reconcile farmers' statements with actual vineyard requirements.

(5) Orchards

(a) Certain trees such as olives, figs and almonds withstand dry soil conditions much better than others such as peaches and apricots. While a general irrigation schedule has been set up for deciduous fruits, it is recognized that water application rates and time of application will vary by species.

(b) Research by Viehmeher and Hendrickson indicate that many trees can obtain water equally well at any moisture content between field capacity and field wilting percentage and that some trees can exist at or near the wilting percentage for several weeks without serious injury, particularly after fruit harvest and in dormant periods. Keeping the moisture content at a high level by frequent irrigation produced no more or better fruit than practices which allow moisture depletion nearly to the field wilting percentage before re-irrigation. 1/

(c) Deciduous trees may draw water uniformly from the soil to 5 or 6 feet. Walnuts have been known to extract moisture to 12 feet in a uniform loam soil. Peach trees may show signs of wilt when the moisture in the top 2 or 3 feet is exhausted. The behaviour of each species in a given soil must be known in order to set up a sound irrigation schedule.

1/ F. J. Viehmeher and A. H. Hendrickson, Proceedings Am. Hort. Soc. Vol. 55, 1950

(d) While deciduous trees may do better if they have readily available moisture at all seasons, the fall irrigation may be reduced or omitted with less danger of injury should lack of water supplies make this necessary. Citrus fruits need enough water throughout the year to keep the soil root zone above the wilting point.

(e) Winter or early spring irrigation to full effective soil depth is desirable but care should be exercised to prevent waterlogging soils over permanent watertables or slowly permeable substrata.

In the Arghandab-Tarnak Area because of conditions imposed by the water supply the following practices are necessary - (a) irrigate so that in January to May inclusive the growing requirements are met and the soil within the root zone is brought to full capacity at the end of May; (b) June, July and August irrigations plus soil storage should meet consumptive use requirements; (c) in September trees may be allowed to nearly deplete soil stored moisture, since most of the fruits except pomegranates will have been harvested; and, (d) October-December irrigations may be kept to the minimum necessary, to prevent complete loss of leaves before frost.

(6) Wheat

Wheat is planted from October through February. Both fall and spring wheats are grown. Irrigations are made usually as follows: (a) pre-irrigation, (b) once in fall months, (c) at 5-leaf stage, (d) at early boot stage, and (e) at milk stage. Fall wheat planted by mid-October on fallowed land appears to give the highest yields. On the other hand, lack of water for fall planting has led to the practice of planting spring wheat using winter and spring rains, spring runoff and limited diversion from the river to complete the crop. In the plans for the Arghandab-Tarnak Area, water for 1/3 of the area is provided for fall planted wheat. Provisions are made for full irrigation through to the 15th-20th of May when irrigation should be discontinued to allow ripening of the grain. Variations in percent of fall and spring wheat and in water applied may be necessary in dry years.

(7) Winter Cover Crops and Legumes

Provision is made over and above orchard and vineyard irrigation for growing winter cover crops and also for winter legumes seeded on cotton land. The winter cover crop might be delayed until November in dry years or omitted altogether.

(8) Other Summer Crops

Truck crops may be planted in spring, summer or fall. It is not expected that the acreage will be high as markets and shipping facilities are not available. The average of several species in each group was used to compute irrigation needs. Summer legumes would be planted on about 1/3 of the wheat land each year there was ample water but would be omitted in years of short water supply.

c. Methods of Computing Water Use by Plants.

(1) The Blaney-Criddle formula comparison was made in Chapter I, Section 2, of the Blaney-Criddle formula and the Meyer formula for determining irrigation water requirements. The Meyer formula uses wind velocity and free water evaporation data along with temperature and humidity.

Because the Blaney formula has been used widely and is generally accepted it is used here. Only in the lower Darweshan, Garmsel and Chakansur Areas would consideration of wind velocities apparently make substantial difference. In the supplemental reports for these areas the wind velocity factor will be shown.

The consumptive use formula, as used by Blaney and Criddle, expressed mathematically, is $U = KF =$ Summation of monthly KF where...

$U =$ Consumptive water use of a crop (or evapo-transpiration) in inches for any period.

$F =$ Sum of the monthly consumptive use factors for the period (sum of the products of the mean monthly temperature and monthly percent of daytime hours of the year).

$K =$ Empirical consumptive water use coefficient (for the irrigation season or a given growing period) based on research studies in similar climates.

$t =$ Mean monthly temperature in degrees Fahrenheit.

$p =$ Monthly percent of daytime hours of the year.

$f = \frac{tp}{100} =$ Monthly consumptive use factor.

$k =$ Monthly consumptive use coefficient.

$u = kf =$ Monthly consumptive use in inches; and

$R =$ Sum of effective monthly precipitation for growing period or irrigation season.

$I = U - R =$ Irrigation requirement for year or growing period.

$E =$ Field-Irrigation efficiency.

$r =$ Monthly precipitation in inches.

$Ie = \frac{U - R}{E} =$ Irrigation requirement at head of field for year or $Iem = \frac{u - r}{E}$ for month. ....has been used in developing irrigation requirements.

The values for K used in this study are those suggested by Blaney and Criddle with modifications based on data from other comparable areas.

Monthly water consumption by crops was determined and an irrigation requirement for each crop was developed in Table 55 . Selection of crops to be used in a rotation, based on their peak demand periods for water may be made from the table. Irrigation is commonly by the check border or contour basin method. With properly controlled application, deep percolation and surface runoff losses can be minimized. Farm efficiency which is practical to obtain was estimated to average 40-60% for vine and fruit crops. All others were valued at 35 50% irrigation efficiency. According to Blaney-Criddle, and Israelson...these assumed irrigation efficiencies are within practical limits. These levels should be easily attainable when farmers are given some training in the importance of careful water management.

Table 7

COMPARISON OF MEASURED AND CALCULATED EVAPORATION FOR HELMAND VALLEY AREAS 1/

8/12/57

	CHAKANSUR AREA					MARJA-LASHKARGA-CHAH-I-ANJIRS					KANDAHAR AREA				
Month	Mean Mo. Temp. F°	% Rel. Humidity	Wind Vel. M.P.H.	Evaporation Calc. inches 2/	Evaporation Meas. Inches	Mean Mo. Temp. F°	% Rel. Humidity	Wind Vel. M.P.H.	Evaporation Calc. Inches	Evaporation Meas. Inches	Mean Mo. Temp. F°	% Rel. Humidity	Wind Vel. M.P.H.	Evaporation Calc. Inches	Evaporation Meas. Inches
Jan.	43.7	55	6.5	2.1	2.6	46	76	4.9	1.1	1.9	44	61	4.0	1.6	1.7
Feb.	50.9	55	8.0	3.0	3.6	53	54	5.3	2.8	2.8	50	58	4.2	2.1	2.6
March	58.3	50	8.5	4.5	4.5	63	54	5.7	4.2	4.1	59	49	4.5	3.7	3.9
April	72.1	42	7.5	8.1	6.9	69	42	8.5	7.6	7.7	69	43	5.0	6.0	6.5
May	83.2	35	8.5	13.7	11.3	82	35	5.8	11.2	10.7	77	37	4.0	8.2	9.0
June	88.8	30	12.0	21.1	19.0	88	33	6.5	14.6	12.8	84	33	4.5	11.6	10.1
July	(93.0)	30	15.0	27.3	20.5	91	30	4.0	14.3	13.1	88	30	5.5	14.4	10.3
Aug.	87.6	25	15.0	25.4	16.2	86	31	3.8	11.8	11.6	84	26	3.5	12.9	10.2
Sept.	77.8	27	10.0	15.1	12.6	79	30	3.7	8.6	8.7	74	26	2.5	7.8	7.4
Oct.	66.7	35	6.5	7.4	8.5	65	38	3.3	5.1	5.7	62	34	2.0	4.4	5.0
Nov.	58.9	45	4.5	4.1	5.5	57	48	3.6	3.3	3.8	53	44	2.0	2.7	3.0
Dec.	49.9	55	4.5	2.3	3.7	49	59	4.3	2.0	2.0	48	54	2.5	1.9	1.9
Totals or Average	69.2	37	8.9	134	115	69	44	4.95	86.7	84.7	66	41	3.7	77.3	71.6

1/ Percentage difference (measured = 100) = Chakansur - 116%, Marja Area - 102%, Kandahar Area - 108%.

2/ Meyer formula: $E_a = 10(e_s - e_a)(1 + \frac{V_w}{10})$ where E_a = monthly evaporation in inches, e_s = saturation vapor pressure in inches of mercury equivalent to mean air temperature in degrees centigrade, e_a = average monthly vapor pressure equivalent to relative humidity, V_w = wind velocity in miles per hour.

(2) Climatic Areas. The watershed area has been divided into three major climatic areas for water use requirements studies. The Tarnak-Arghandab Area has been studied and reported in a separate report. 1/ The central Helmand Valley and Lower Helmand-Chakansur Areas are hotter, have longer growth, seasonal and somewhat different latitudes.

Tables 53. and 54, show the computed "f" factor for the central and lower Helmand Areas as compared with Kandahar. The correction factors shown are used to adjust crop requirements from Chart 55 to the area concerned.

d. Water Requirements of Crops Grown in S. W. Afghanistan.

The series of large charts, Table 55, (4 pages) brings together the combined effects of climate, growing seasons and water use habits of the crops which may be grown. For each crop the normal land preparation and seeding period, actively growing period and period of harvest, dormancy or fallow are given. The consumptive use in acre-inches per month of active growth are indicated. For some crops the variations in percentage of total water used is shown by months. The range of seasonal consumptive use and common or average use is given at the right of each crop together with the seasonal variation and averages of the consumptive use coefficients.

The chart allows the choice of rotations for a given soil to be so selected as to allow one or several crops a year. The consumptive use of each crop can be quickly computed. By application of known or assumed water delivery and farm irrigation efficiencies the amount of water necessary to divert and deliver to the farm head-gate each month can be determined. As explained in the footnotes to the chart there are many local variations that must be worked out by the farmers themselves for full knowledge of the absolute requirements of all crops would require years of research. These data based on all available information will serve as a general guide, however.

Conversion factors for the central and lower Helmand areas are given on page 4 of the chart. These are based on differences in average monthly temperatures and monthly percentages of total sunshine hours as given in Tables 53 and 54. Consumptive use calculated by these conversion factors compare Lower Helmand with such areas as Mesa and Tucson, Arizona. When the wind velocity factor from Table 8, Chapter I is applied, exaggerated use coefficients 160-180% higher result. Until field experience furnishes some evidence of the effect of the high summer winds of the Chakansur on Water use by crops, the Blaney-Criddle formula will serve as a reasonable guide to consumptive use.

Water use requirements by crops and by projects are included in the supplementary reports. A summary of these for the Arghandab-Tarnak projects has been reported on in the water allocations study. The calculated crop use, farm delivery and diversion requirements for Helmand projects under command of Helmand River water are summarized in Table 56.

1/ Tarnak-Arghandab Water Allocations Report, July, 1956.

TABLE 53 July 11, 1957

COMPUTATION OF CONSUMPTIVE USE FACTORS FOR CENTRAL HELMAND VALLEY AREA

Month	Mean Annual Temperature - F°				% Total Sunshine Hours	f Factor =tp/100	Corr. 1/ factor u' = uf'/f	Wt'ed mean mo. Cons. Use of all Crops 2/ Inches	Diversion req. Acrefeet/Acre 2/
	Marja	Chah-i-Anjirs	Lash-kar-ga	Weighted Mean					
Jan.	46.7	45.8	46.5	46.24	7.220	3.34	1.0536	1.01	0.19
Feb.	53.3	52.1	51.5	52.14	6.990	3.64	1.0769	1.08	0.20
Mar.	62.5	60.9	61.3	61.39	8.370	5.14	1.0731	1.47	0.28
Apr.	73.0	75.0	56.9	67.73	8.740	5.92	1.0103	2.50	0.47
May	83.8	83.9	79.5	82.20	9.600	7.89	1.0867	4.49	0.85
June	87.7	89.2	85.5	87.72	9.570	8.39	1.0825	4.02	0.76
July	93.0	92.2	89.0	91.26	9.745	8.89	1.0775	4.97	0.94
Aug.	87.2	85.4	85.6	85.77	9.270	7.95	1.0515	4.11	0.78
Sept.	80.6	77.9	77.4	78.18	8.340	6.52	1.0724	2.21	0.42
Oct.	66.3	66.4	62.9	65.22	7.950	5.18	1.0237	0.93	0.18
Nov.	58.5	55.2	56.6	56.22	7.130	4.00	1.0498	0.48	0.09
Dec.	49.3	48.8	47.9	48.58	7.080	3.44	1.0990	0.87	0.16
Totals	841.9	832.8	800.1	822.65	100.00	70.30	12.7570	28.14	5.33
Means	70.1	69.4	66.6	68.55	----	----	1.0631	----	----

1/ Relation of Marja-Chah-i-Anjirs-Lashkarga area to Kandahar is expressed by equation $u' = \frac{uf'}{f}$ where u'f' represents the area and uf the Kandahar data.

2/ This comparison is based on the weighted mean value of consumptive use of all crops adjusted to the total area of 185,000 acres of the Arghandab-Tarnak area. The figure is valid only if the same cropping pattern and irrigation efficiencies are used. (See Arghandab-Tarnak Area Water Allocation Study - 7/56).

TABLE 54

July 13, 1957

COMPUTATION OF CONSUMPTIVE USE FACTORS FOR LOWER HELMAND AREAS

Month	Mean Annual Temperature-F° Kala Kang	Farah	Darweshan Est.	Weighted Mean 3 Stations	Total Sunshine Hours % of Annual 30° 45' N	"f" factor = tp/100	Corr. factor 1/ $u' = \frac{uf'}{f}$	Wt'd mean Cons. Use All Crops Inches 2/	Diversion req. Acrefeet/Acre 2/
Jan.	43.7	52.3	46	46.5	7.2695	3.38	1.0662	1.02	0.19
Feb.	50.9	57.8	52	53.08	7.0075	3.72	1.1005	1.10	0.21
Mar.	58.3	67.7	60	60.99	8.3763	5.11	1.0669	1.46	0.28
April	72.1	72.2	69	71.82	8.7313	6.27	1.0699	2.65	0.50
May	83.2	82.1	82	82.75	9.5675	7.92	1.0909	4.51	0.85
June	88.8	86.8	88	88.12	9.5313	8.40	1.0838	4.02	0.76
July	92.1	93.7	91.5	92.52	9.7075	8.98	1.0884	5.02	0.95
Aug.	87.6	87.3	87	87.45	9.2424	8.08	1.0688	4.18	0.79
Sept.	77.8	77.8	78	77.82	8.3400	6.49	1.0674	2.20	0.42
Oct.	66.7	68.0	67	67.12	7.9675	5.35	1.0573	0.96	0.18
Nov.	58.9	66.3	58	61.03	7.1600	4.37	1.1469	0.53	0.10
Dec.	49.9	59.0	49	52.54	7.1063	3.73	1.1916	0.94	0.18
Totals	830.9	871.6	827.5	842.77	100.00	71.80	12.10986	28.59"	5.41'
Means	69.2	72.4	69.0	70.23	—	—	1.09155	—	—
Years	6	3							
Records Partial - (est.)				—	—	—	—	—	—

1/ Relation of Lower Helmand Area to Kandahar Area is expressed by equation $u' = \frac{uf'}{f}$ where u'f' represents the area and uf the Kandahar data.

2/ This comparison is based on the weighted mean value of consumptive use of all crops adjusted to the total area of 185,000 acres of the Arghandab-Tarnak Area. The figure is valid only if the same cropping pattern and irrigation efficiencies are used. (See Arghandab-Tarnak Area Water Allocation Study 7/56).

3. Fertilizers

A brief report on the need for and cost of fertilizers for S. W. Afghanistan was made in 1955 1/, and a study of possible fertilizer production was included in the Industrial Survey Report 2/. Geologic and mineral surveys, all of a general nature, have thus far failed to reveal fertilizer raw materials in Afghanistan. Some small guano deposits of relatively little significance were located.

Many Afghanistan soils have been used over several centuries. If present agriculture reflects past usage little or nothing has been done to restore or improve soil fertility other than by fallow methods which so far as observed consist of periods of abandonment of 1-5 years. This is one reason other than water shortage why one observes only 1/2-1/5 of the land annually cropped. Continuous cropping to wheat at Nad-i-Ali resulted in yields from the first year to four years out of desert of 18, 12, 8 and (5-3) bushels, respectively. All straw and wheat is completely removed and the land left barren after harvest. It can be said that the fertility levels of most of the land over the Helmand is at a minimum level. Near villages and large towns the use of animal manures and night soil has maintained a few acres at higher levels.

Small amounts of nitrogen are added to the soil by rainfall and irrigation water. Non-symbiotic bacteria (live without host plant or legumes) may take from the air several pounds of nitrogen. A few leguminous plants such as camel thorn grow in fallowed fields and help fix nitrogen. Thus by leaving the land idle one or two years sufficient nitrogen may be recovered to produce another meagre crop.

Much can be done without fertilizers to build up soil productivity and tilth. The following illustrates the nitrogen regime in an irrigated soil:

Table 57

Additions to Nitrogen		Removal of Nitrogen	
Irrigation and rainfall	6 - 10 #	Crops	120-200 #
1 ton of straw turned under	8 - 12 #	Leach. losses	5-50 #
Wasted seeds	1.5-3.5 #	Atmospheric	
Legume crop turned under	100-200 #	losses or	
Non-symbiotic fixation	25-50 #	others	2.5-25 #
Nitrogen additions	140-275 #		140-275 #

Thus without fertilizers but with proper attention to growth of legume crops and turning these under at the right stage will provide nitrogen to produce several times the yield now being produced on the average Afghan farm.

Table 58, gives the amounts of plant food normally removed by different crops at the levels of production expected at different stages or levels of irrigation development and irrigation farming. It can be seen that high production will require utilizing every means possible to build and maintain a high fertility level. The cheapest most available sources must be used at first. Of these, as shown above, leguminous crops are good sources of nitrogen. The value of the crop for green manure is not greatly reduced if grazed moderately and the animal droppings allowed to return to the soil. Table 59, shows the fertilizer value of excrement and bedding from different animals. The fertilizer value per year at present commercial

1/ Fertilizer problems in Southern Afghanistan - 3/18/55, MKA Land Dev. Division.
2/ Helmand Valley Industrial Survey, Phase I, MKA., November, 1955

Table 58 PLANT FOOD REQUIREMENTS FOR DIFFERENT LEVELS OF PRODUCTION August 22, 1956

Crops		Yields At Different Levels of Production				Plant Food Removed By Crops At Different Yield Levels											
						1st Stage			2nd Stage			3rd Stage			4th Stage		
Gen. ratio		1.0	2.0	4.0	6.25	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O
Stage of Dev.		1	2	3	4												
Wheat	Bu.	7.5	15	30	50	9	5.6	7	18	10	14	51	20	27	80	34	46
Barley	Bu.	15	25	45	75	18	7.5	15	30	12	26	54	22.5	47	95	39	87
Corn	Bu.	10	20	50	100	19	8	14	38	20	30	75	32	55	160	90	150
Rice	Ts.	0.4	.75	1.5	2.5	13	4	5	24	7.5	9	54	16	30	85	25	40
Gr. Sorghum	Ts.	0.25	0.5	1.0	1.5	31	7	14	70	16	30	140	32	60	200	45	85
Sorghum forage	Ts.	2.0	4.0	6.0	10.0	50	24	40	100	48	80	150	72	120	250	120	200
Grapes	Ts.	2.25	4.50	9.0	14.0	6	3.3	11	11	6.8	23	23	14	45	35	21	70
Peaches	Bu.	50	150	250	500	3.0	1.5	7.0	9.0	4.0	21	15	6.0	35	30	12.5	70
Apples	Bu.	50	100	300	500	2.5	0.9	4.0	5	1.75	7.5	15	5.25	22.5	25	10	37.5
Pears	Ts.	50	100	300	500	3.0	1.5	7.0	6.0	3.0	14.0	18.0	9.0	54	30	15	70
Apricots	Ts.	75	1.5	3.3	4.8	2.4	0.8	1.9	5.0	1.6	4.0	11	4.0	8.0	15	5.0	12.0
Figs dried	Cwt.	2	5	10	20	1.4	.5	2.0	3.4	1.3	5.2	7.0	2.65	11	14	5.3	22
Dates	Ts.	1.5	3	6	8	10	6	25	20	12	50	40	24	100	54	34	136
Pomegranates	Ts.	2	3.0	7.5	10	1.2	3.2	13	14	5.0	19	36	12	48	48	16	64
Walnuts	Cwt.	2	5	10	15	7	2	3	18	5	7.5	37	[illegible]	13	[illegible]	[illegible]	23
Almonds	Cwt.	1	2.0	4.0	10.0	3.3	1.3	1.5	7	2.7	3.0	15	5.2	6.0	34	13.4	15
Cotton + seed	Cwt.	3	6	15	25	8	3	9	16	16	18	40	16	46	67	27	77
[illegible]	Ts.	2	6	10	15	13	5	21	39	14	63	65	23	105	97	35	157
Olives	Ts.	1	2	4	6	2.5	.75	2.4	5.0	1.5	4.8	10.0	3.0	9.6	15.0	5.0	15
Beans (dry)	Cwt.	2.5	5	10	15	9	2	3.5	18	4	7	36	8	14	54	12	21
Sugar Beets	Ts.	5	10	15	20	25	8	20	50	15	40	76	23	60	100	31	80
Potatoes	Bu.	50	100	300	600	11	5	16	21	9	32	63	27	96	126	54	192
Oil Seeds	Cwt.	5	8	16	25	14	3	4	28	6	8	56	12	16	82	19	25
Alfalfa	Ts.	1.5	3	6	9	75	17	60	135	33	120	300	66	240	450	100	360
Sw. Clover	Ts.	1.0	2.0	4.0	6.0	41	8	32	82	16	65	164	32	130	246	48	195
Ladino	Ts.	1.0	2.0	4.0	6.0	41	8	32	82	16	65	164	32	130	246	48	195
Bluegrass	Ts.	.5	1.0	2.0	3	14	6	21	27	11	42	56	22	84	81	33	126
Bermuda	Ts.	.5	0.75	1.0	1.5	11	7.5	24	17	11	18	22	15	48	33	23	72
Dallis	Ts.	.5	1.0	1.5	2.0	19	6	16	38	12	33	57	18	50	76	24	66
Sudan	Ts.	2	4	6	8	50	24	40	100	48	80	150	72	120	200	96	160
Peas (dry)	Cwt.	2.5	5	10	15	9	2	3.5	18	4	7	36	8	14	54	12	21
Tomatoes	Ts.	2	5	10	15	10	4	16	27	10	30	50	18	75	75	26	112
Gen. Veg.	Ts.	1.25	2.5	5.0	8.0	44	16	18	87	31	38	175	62	75	280	100	120
Melons	Ts.	3	6	12	20	6.0	1.5	10	12	3	20	24	6	40	36	9	66

PLANT NUTRIENTS IN ONE TON OF DIFFERENT MANURES #
(Includes solid, liquid and bedding)

Table 59

August 22, 1956

Kind of Animal	Nitrogen (N) Pounds	Phosphoric Acid (P_2O_5) Pounds	Potash (K_2O) Pounds	Tons Manure Produced per Year per 1000 Lbs. Live Wt.
Horse	13.2	5.1	12.1	12
Cow	11.4	3.1	9.9	15
Pig	9.9	6.7	9.3	18½
Sheep	15.8	6.7	18.0	9 3/4
Steer	15.0	6.0	8.0	9
Hen	21.0	16.4	10.2	4½
Duck	11.4	28.8	9.8	

Source: Cornell University

From "Our Land and its Care", Prepared and published by the American Plant Food Council, Inc., 910 17th St., N. W., Washington 6, D. C., in cooperation with the Agricultural Education Service, U. S. Office of Education, Federal Security Agency, Washington, D. C.

NOTE: To preserve manures add 25-30 # of 40 % superphosphate to poultry or cattle manures and 40 # to horse, sheep and goat manurs. Use about 9 # of straw per cow for bedding per day and 1 # per day for sheep in feed lots. All manure composts should be layered with bedding and fertilizer and protected from rains and from extreme heat.

Table 8

COMPARISON OF IRRIGATION REQUIREMENTS BY DIFFERENT METHODS

8/12/58

Area	Mean Annual Evaporation	Per Acre Mean Consumptive Use Ut:Et	Consumptive Use Minus Rainfall	Farm Delivery Req. at 55% I.E.	Diversion Req. @ 75% Delivery ≠ 5% Ret. Flow
Arghandab	63.84	1.98 2/	1.45	2.63	3.29
(106.5) 4/	——	2.40 4/	1.85	3.36	4.20
Kandahar	77.3	2.40 3/	1.96	3.56	4.45
(1.00)	72.52	2.25 1/	1.81 (1.9)	3.45	4.30
Marja (Gen.Area)	84.7	2.63 2/	2.34	4.25	5.31
——	86.7	2.69 3/	2.40	4.36	5.45
(1.063)	——	2.39 4/	2.10	3.81	4.76
Darweshan *	106.1	3.34 3/	3.08	5.60	7.00
(1.078) 4/	——	2.43 4/	2.17	3.94	4.93
Chakansur	115	3.56 2/	3.40	6.18	7.72
——	134	3.89 3/	4.15	7.55	9.44
(1.092) 4/	——	2.46 4/	2.30	4.18	5.23

1/ Kandahar data has been thoroughly studied in previous reports and is used here as basis for comparison.

2/ Assuming evapo-transpiration can be compared on basis of differences in free water evaporation as measured in open pans.

3/ Assuming same relationship as above but computing evaporation by the Meyer formula which involves the wind velocity as one factor determining evaporation.

4/ Based on ratio of computed consumptive use factors using Blaney-Criddle formula.

* Interpolated from other station records.

prices of fertilizer elements; for 1,000 # live weight and of animals, is horse - $41.40, cow - $83.40, steer - $30.78, pig - $52.92, sheep or goat - $44.16, chicken - $24.75 and duck - $26.80. The burning of dung for fuel is a wasteful practice. No fertilizer is of greater value in soil improvement than animal manures. Commercial fertilizers are more effective when applied with liberal quantities of manures. Other organic fertilizers may also be used such as straw, cotton burrs, and kitchen refuse. Table 60, lists a number of other organic fertilizers and their average analysis.

The cost of fertilizers is the greatest detriment to their use in Afghanistan. The long boat, rail and truck haul makes shipping costs equal to or greater than the wholesale (1942 price study) fertilizer prices, F.O.B., U. S. east coast. In the 1955 report on fertilizer needs of S. W. Afghanistan it was pointed out that the beginning of fertilizer usage in any measurable degree might be 15-20 years after project development. Ultimately 50-60% of the land could make profitable use of fertilizers. Table 61, taken from the former report shows the gross fertilizer needs of S. W. Afghanistan based on the crop acreages shown in the 1953 report. There will be some shifting in crops from that shown as well as in the total acreage of crop land. The general estimate is fair, however, and may be adjusted percentagewise to the land area finally determined irrigable.

In the above mentioned report it was shown that the annual shipment cost alone of fertilizers purchased abroad could amount to $760,000-$3,500,000 on the amount shown in Table 61, as needed. Savings in freightage costs could easily amortize investments of 15-50 million dollars in developing local fertilizer manufacturing.

The potential need for fertilizers in the Helmand Valley alone justifies intensive search for suitable minerals within the country and a thorough study of their development costs, if found. The prior emphasis on searches for sources of power and fuel is necessary since these will be needed in the processing of fertilizers. Considerable electric power can be made available at Kajakai and Arghandab.

Freight costs alone for shipment over the great distances from external fertilizer sources may amount to more than the amortization costs of adequate fertilizer plants to serve the country's needs.

Potential production without use of fertilizers has been liberally estimated. Such production can be obtained only if proper drainage and irrigation practices are coupled with the liberal use of green manures and legume crops, and maintenance of suitable controls over salinity, alkalinity and erosion. On the older soils particularly, and on all lands as irrigation proceeds, yields will tend to decrease without fertilizers. Maintenance of yields adequate to justify the major agricultural development now going on in the Helmand Basin cannot be obtained unless sound soil fertility practices are invoked.

The above study would indicate that search for phosphate-bearing minerals is of first importance. Sulphur and coal deposits now known may be adequate for processing but deposits nearer the Helmand development area may be found. Potash deposits are of much less importance but nevertheless search for these should be included. Local nitrate beds would be valuable if found, however, fixation of atmospheric nitrogen will more than likely be the best source of this plant food element.

AVERAGE ANALYSIS OF ORGANIC MATERIALS *

Table 60 August 22, 1956

Bulky Organic Materials	Percent Nitrogen N	Percent Phosphorous P_2O_5	Percent Potassium K_2O	Percent Organic Matter	Cubic Feet per Ton
Goat manure	2.77	1.78	2.88	60	70
Dairy manure	.7	.30	.65	30	55
Steer manure	2.0	.54	1.92	60	70
Horse manure	.7	.34	.52	60	75
Hog manure	1.0	.75	.85	30	60
Sheep manure	2.0	1.00	2.50	60	70
Rabbit manure	2.0	1.33	1.20	50	70
Poultry manure	1.6	1.25	.9	50	50
Seaweed (kelp)	.2	.1	.6	80	—
Alfalfa hay	2.5	.50	2.10	85	—
Alfalfa straw	1.5	.30	1.50	82	—
Bean straw	1.2	.25	1.25	82	—
Grain straw	.6	.20	1.10	80	—
Cotton bolls	1.0	.15	4.0	80	—
Winery pomace (dried)	1 to 2.0	1.5	0.5—1.0	80	—
Olive pomace	1.2	.8	.5	80	—
Poultry droppings	4.0	3.2	1.9	74	55
Organic Concentrates	N%	P_2O_5%	K_2O%		O.M.%
Dried blood	13.0	1.5	—		80
Fish meal	10.4	5.9	—		80
Septic sludge (digested)	2.0	3.01	—		50
Nitroganic	6.5	3.4	.3		80
Tankage	7.0	8.6	1.5		80
Cottonseed meal	6.5	3.0	1.5		80
Bat guano	13.0	5.0	2.0		30
Bone meal	4.1	30.0	—		—
Castor pomace	6.0	2.5-3	.5		80

Bat guano due to conditions under which it is taken from caves varies widely. Recent deposits are high in nitrogen often 8-13% N, 4-5% P_2O_5 and 2% K_2O. Older deposits run 1-4% N and 10-20% P_2O_5 with very little potash (K_2O) content. These percentage figures are therefore only comparative.

All organic materials should be purchased on the basis of actual analysis. There is a wide variation in value due to moisture content, type of storage, and other conditions. The above values are averages only taken from official literature.

*From Western Fertilizer Handbook, published and distributed by Soil Improvement Committee, California Fertilizer Association, 475 Huntington Dr. San Marino, California.

Table 61 — ESTIMATED GROSS FERTILIZER NEEDS OF S. W. AFGHANISTAN WHEN FULLY DEVELOPED UNDER IRRIGATION — 8/21/57

Crops	Gross Irrigable Lands (1954)	Estimated Mean Fertilizer Needs (# Per Acre) N	P_2O_5	K_2O*** (1/2 Acreage)	Tons - Fertilizer Needed Estimated As $(NH_4)_2SO_4$	40% Super-Phosphate	K_2SO_4*** (1/2 Acreage)
**Wheat	218,350	10	40	10***	5,141	10,917	1,010
Corn	25,000	80	80	40	4,716	2,500	463
Alfalfa & clovers	150,000	--	100	50	-	35,370	3,468
Sugar beets	53,000	80	120	-	9,997	7,950	-
Special Oil Seed Crops	37,724	60	40	20	5,337	1,886	349
Cotton	82,424	64	64	32	12,439	6,594	1,220
Fruits and nuts	111,756	80	160	80	21,082	22,360	4,135
Grapes	55,877	32	32	64	4,216	2,235	1,654
**Peas & beans (green-manures)	120,664	10	40	20	2,845	6,033	1,116
Irrigated Pasture	200,000	32	96	32	15,091	24,000	2,960
*Vegetables	64,631	120	40	80	18,288	3,231	2,391
*Rice	23,590	60	60	30	3,337	1,769	327
*Potatoes	24,645	60	40	40	3,488	1,232	456
*Sorghums	25,000	60	40	20	3,537	2,358	231
		(38.9)	(86)	(35.8)	109,514	128,435	19,780
	Total tonnage for 100% development & peak use						- 257,729

Double Cropping	136%
Acres doubled cropped	316,581
Total Crop Acres	1,192,661
Total Land Area	876,080

*Acreages of rice, potatoes, vegetables and sorghums were increased over general report to balance farm family and urban needs.

**Reductions were made in wheat and pulses to give double cropping of 136% given in the report.

***Potash fertilizers are assumed to be needed on 1/2 the cropped acreage. (Cash crops underscored)

CHAPTER VII

TILLAGE AND WATER USE PRACTICES

One cannot stress too strongly that a well-engineered irrigation layout does not guarantee crop production. The advantage is in favor of the farmer who is willing to use it but, by and large, the success of an irrigation development will depend on how well the farmer understands his problems and undertakes to solve them.

1. Tillage and general farming practices. A number of poor cultural and water use practices contribute as much to low production in Afghanistan as antiquated and inadequate irrigation systems. F. O. Youngs in summarizing his work in Afghanistan had this to say of Afghan farming practices:

1. "Selection of Crops and Good Seed. Next to adequate water supply, drainage and high fertility, proper selection of crops is most important. By this is meant growing the kinds of crops that will be most productive and valuable and by using the best varieties and the highest quality of seed. For food crops, improved varieties of wheat, corn, sweet corn, vegetables, potatoes, sweet potatoes and peanuts will be very valuable. Cotton, sugar beets and tobacco will be valuable money crops. Alfalfa and clovers will make it possible to produce more and better livestock and livestock products. Multiplication of seed of good proven varieties will be an important part of the agricultural development program. (Note: Afghan corn produces 1/4-1/2 of American varieties given similar treatment).

2. Improved Methods of Planting and Irrigation. Low yields of crops commonly grown by farmers in the Helmand Valley are due, to an important extent, to poor methods of planting, irrigation and cultivation. Both corn and cotton are commonly sown broadcast and irrigated by flooding of basins. According to experiments, as well as field experience, these crops usually do much better when planted in rows on ridges and irrigated by furrows. It has been learned, however, that ridge planting and furrow irrigation of crops or trees is very poor practice (if carried on continuously) on saline soils and is safe only where the salinity problem is negligible. The thorough leaching out of salts by liberal irrigation in flat basins is essential to prepare saline soils for crop production, or growing of trees.

3. Control of Weeds, Insects and Plant Diseases. Weeds are becoming a serious threat to agriculture in the Helmand Valley; their control is imperative. Cultivation is conspicuous by its absence in most of the fields of Afghan farmers in the Helmand Valley. Only a few of the vegetable crops are commonly grown in rows. In such crops as wheat, corn and cotton, which are sown broadcast, the weeds are sometimes pulled by hand. (In most fields weeds grow without control). Row planting of crops would allow cultivation and hoeing to control weeds. Chemical sprays should be tried to control troublesome weeds such as camel thorn. (Every farmer should be taught how to use simple farm tools which he and his oxen can handle but which are an improvement over those he now owns.)

Locusts are a frequent threat to growing crops in the Helmand Valley. Army worms, cabbage worms, aphids, and melon flies have also done much damage. Various sprays and poison baits should be used at critical times.

Such diseases as wheat smut and rust occur in certain years of unusually high humidity. Selection of resistant varieties and strains is needed. According to some observations, a few of the American strains appear to be more resistant than most Afghan wheats, although the latter may be better adapted to conditions in the drier years.

4. Improvement of Farming in Older Areas. It seems that much greater emphasis should be placed on improvement of agriculture in the areas where farming has been carried on for long periods. The farmers in some of these areas are already taking advantages of the increased and stabilized water supply resulting from the building of the Arghandab and Kajakai dams and the new canals. They can raise a larger acreage and a wider variety of crops, obtain higher yields and make a higher income from the land; but they need help in the way of better seed, better livestock, and instructions in improved farming practices in order to take full advantage of the improved water supply.

5. (Management of Irrigation Districts). These problems are physical, including adverse conditions of soil, salinity and drainage, and a climate in which no farming is possible without irrigation; and administrative, including proper selection and allotment of land, selection of settlers to farm the land and providing housing, implements, seed, livestock and capital until the farmers can become self-supporting. Also, the operation and maintenance of dams, canals and water distribution and drainage systems is a major problem; and proper control of the use of water on the land is a crying need."

2. Water Management.

a. Present conditions - Water use and water management as commonly practiced in Afghanistan operates at a very low efficiency. Much of the cause is the inadequate, makeshift, irrigation systems which have been in common use for centuries. Among some of the practices leading to waste of water are

(1) Brush and loose stone diversions which go out with each flood causing loss of irrigation water and damage to crops even when ample supplies are available;

(2) No controls at the intakes so that, if they do not wash out, large uncontrollable flows pass on to the farm areas flooding the lower places washing out ditches, damaging crops and adding to ground water already high from over irrigation.

(3) Over-exaggerated independence of individuals, villages, clans and tribes which leads to construction of parallel systems from the river inward - as many as 6 to 10 main ditches, each with its own brush and rock diversion, have been observed running parallel and almost touching each other for miles. There is tremendous water loss through breaks and seepage from these ditches.

(4) Improper grades, unlined channels through gravelly and sandy stretches, substitution of winding channels for checkdrops, and the generally loose unbonded, uncompacted banks of these hand dug ditches leads to tremendous seepage losses;

(5) Lack of weed and brush control so that large amounts of water is used by vegetation along the numerous canals and ditches.

(6) An exaggerated application of the riparian principles of water allocation - first come, take all practice - leads to waste on the upper reaches and acute shortages on the lower reaches of any system. An example that is having an

overly emphasized effect on long range planning occured in 1955 on the Arghandab. This was the driest water year on record, also the year when Tarnak-Arghandab development was being discussed between agencies and countries. People on the lower ends of the extremely long winding ditches and down the Arghandab were short of water. At the same time the Patow and Zanzigar ditches were taking in a lion's share of the water - much more than they could possibly use efficiently. So the cry "water shortage" went up and even some Americans turned against further expansion of land areas into the Tarnak thinking that the 1955 year was a demonstration of acute water shortage. Impartial studies show it would have been a short water year had all three project areas been fully developed. About 1/4 of all the years of rainfall - runoff records indicate a low (60-70%) supply. For the land cultivated in 1955, however, there was adequate water - inefficient use and distribution as described above made an otherwise adequate supply seem insufficient for crop needs. The coincidence of the 1955 water use experience with Tarnak development proposals is the principal reason for delays in completion of the Tarnak system. This is despite undisputable proof of abundant water seven years out of 10 and fair assurance 14 of 19 with 60-70% of that needed in the remaining 25-30% of the years.

(7) Farm irrigation is generally haphazard and carelessly done where water supplies are abundant - this leads to great wastage through surface runoff and percolation into the ground water table. A so called "basin" system is used by the Afghans. Properly laid out and properly irrigated the contour basin system could be highly efficient. However, the Afghan practice is to let the water run continuously through all the small irregular checks or basins until the lower ends are reached. It is more a system of wild-flooding with checks. As a consequence serious over irrigation occurs on the upper parts of fields - the last checks may not get enough. Attempts were made at Nad-i-Ali to take a very simple step forward by placing a small feeder ditch between rows of check basins so that by irrigating first from the lower end and in turn back to the head ditch each basin could be properly filled and there would be little wastage. Some few farmers have caught the idea. An irrigation efficiency check made in 1956 revealed, however, that most farmers had gone back to their old ways or else were filling all basins to overflowing regardless of soil needs. Irrigation efficiencies were on the order of 20-25%. Demonstrations made for the farmers using their own facilities proved that, where the farm ditches and border feeder ditches were in good state of repair, 60-80% farm irrigation efficiency could be obtained even on Nad-i-Ali soils.

(8) Water irrigation schedules and water allocations are seldom heard of except as arranged by "bakshish" (bribery), "jang-jang" (fisticuffs) and "ab-ila-dadan" (downright vandalism). In the Nad-i-Ali, where a sound rotation irrigation schedule and water allocation plan could have greatly reduced water losses and ground water troubles, the three malpractices described above became so prevalent that three ICA water engineers spent their entire contracts in the area and failed to get a water management program. Every farmer and every village chief wants the water running continuously by his door - he seems to think he has been provided with a permanent stream to be his own. Since these are all unlined, earthen ditches the water loss is very high - and the high water tables reflect this misuse of an irrigation system.

b. Improvement of water use practices. Contrary to the practices described above some very highly efficient use of water has been observed where karezes of low capacity have been the only source of water for farm areas. One second-foot has been reported to serve 100-150 acres under such conditions.

It is recognized that obtaining efficient use of water will be a long hard struggle. Education, demonstration, organization and enforcement of regulations will require years to put into operation. Probably the most effective control would be to set up allocations and sell the water to the farmer. Calculated farm delivery requirements could be sold at a nominal figure - any excess water used should require a stiff fee. This would require measuring devices, use-records and a system of ditch management that would take a long time to perfect. The Afghan farmer, if made to realize that each excess acre-foot used would cost him a stiff fee, would by nature reduce his water usage and be more receptive to learning ways and means of conserving water. Revenues badly needed for operation and maintenance could come from water-right assessments. The joint agency committee which reviewed and approved the allocation of water to the Tarnak Area 1/, made the following recommendations which apply generally to all of S. W. Afghanistan:

(1) Construction of controlled intakes at all major diversions.

(2) Combining of many of the parallel ditches.

(3) Construction of proportional dividers where several ditches are supplies from a common canal.

(4) Construction of wasteways at tail end of ditches.

(5) Rehabilitation or relocation of small stretches of canals.

(6) Construction of culverts or overpasses for surface drainage crossings.

(7) Repair of canal banks.

(8) Lining of leaky canal stretches.

(9) Adjustment of canal capacities according to irrigation requirements.

(10) A complete and efficient irrigation and distribution system, coupled with good water management on all lands.

(11) Adequate surface and sub-surface system for disposal or reuse of excess waters from the land.

(12) Reclamation of saline, alkaline and wet areas.

(13) Establishment of a crop rotation and cropping system best adapted to each soil class and which is capable of maintaining fertility, tilth and high production of the different soils.

F. O. Youngs adds:

(14) "Establish and put into operation an organization for the proper operation and maintenance of the entire irrigation and drainage system.

(15) Establish and put into operation an organization to work with the farmers of all areas of the Helmand Valley to teach and demonstrate the use of improved agricultural and irrigation practices".

1/ Joint committee report of ICA-HVA-MKA and Karl O. Kohler, August 4, 1955.

c. Adapting irrigation systems to soil conditions. One of the faults of mass land development is the tendency to establish a uniform design on all soil types and slopes. This leads to lack of sufficient capacity for some soils and over design and unnecessary costs on others. Similarly, stressing the use of basin irrigation fails to give proper values to the use of a number of other systems which may locally be most effective for given crops such as row or furrow irrigation for cotton, corn, sugar beets and truck crops, border irrigation for small grains, contour-border and broad furrow irrigation of orchards and the use of corrugations on heavy soils, for sloping pastures, and supplementary to border irrigation. There is no one best method nor one best design. Each soil type, slope condition and combination of site factors may be best handled by a modification of some sort. Much of this must be worked out with the farmer on his own land and is beyond the scope of this report. The major characteristics of soils affecting water requirements and irrigation design are summarized here for use.

Several tables have been prepared from a study of the characteristics of Afghanistan soils and application of irrigation principles. 1/, 2/, 3/.

(1) Field interpretation of soil moisture - Many farmers irrigate as soon as a dry crust forms in the upper 2"-4" of soil. Actual measurements made in the Nad-i-Ali showed less than 1" to 1½" intake capacity at the time farmers were putting 4"-6" of water into some check basins. Table 62, shows practical field methods of estimating when soil moisture has dropped low enough to require irrigation. The top four inches of soil should be ignored except in the early stages of plant growth. This layer dries out quickly under the desert sun and hot winds and usually serves as a mulch. Every effort should be made to encourage deeper root growth. The 4"-18" layer is most critical layer for irrigation as a large number of plants will have 50% or more of their roots concentrated in this zone and 30%-90% of the moisture may be extracted from here for different soil depths and textures. The criteria of Table 62, should be applied in such a way as to determine when the 4"-18" layer (usually 4"-12") falls at or slightly below 50% of field capacity. Irrigation should begin once the 50% level is passed as some parts of the field may suffer for water if the top foot is allowed to dry out before irrigation begins. The appearance of the plants is another and very good criteria of water needs. Wheat will begin to turn a bluish-green color and the lower leaves become harsh and bristly if available water reaches too slow a level. Cotton leaves may become flaccid or limp on hot afternoons but recover in the cool of the night. If the flaccid condition persists during the night water is definitely needed. Corn leaves curl in extreme heat but unfurl and resume their rigidity at night. If curling persists through the night water is needed. These are not always exact indicators as there may be other causes of leaf curl or flaccidity. By comparing soil moisture conditions and plant growth one can learn to recognize when irrigation is required.

1/ Methods for evaluating irrigation systems, Handbook, 82, U.S.D.A., S.C.S., April, 1956.
2/ Capacity of soil to hold moisture - D. R. Shockley, Agric. Engineer, Feb., 1955
3/ Irrigation (texts) - Houk, Israelson, (others).

TABLE 62 - PRACTICAL INTERPRETATION CHART FOR SOIL MOISTURE

Percent of RAM Remaining	Feel or appearance of soils	
	Textural group: "F" (Moderately heavy) Textural grades: sandy clay loam, silty clay loam, and clay loam Textural group: H (Heavy) Textural grade: sandy clay	Textural group: "M" (Medium) Textural grades: sandy loam, fine sandy loam, very fine sandy loam, loam, and silt loam
0	Hard, baked, cracked, sometimes has loose crumbs on surface	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition
50 or less	Somewhat pliable, will ball under pressure*	Somewhat crumbly, but will hold together from pressure
50-75	Forms a ball; will ribbon out between thumb and forefinger	Forms a ball*, somewhat pliable, will sometimes slick slightly with pressure
75 to field capacity	Easily ribbons out between fingers; has a slick feeling	Forms a ball and is pliable, slicks readily if relatively high in clay
At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand	Same as "F" group
Above field capacity	Puddles and free water forms on surface	Can squeeze out free water

*Ball is formed by squeezing handful of soil with fingers

(2) Irrigation unit stream - The amount or head of water required to properly irrigate a strip of land depends on the capacity of the area to hold water, the rates of intake (initial and final), the slope, method of irrigation and resistance to flow of vegetation and ground surface. Three basic soil factors which can be used for irrigation design are the rate of intake, the water-holding capacity and the slope. Since the general average slope of most Afghanistan projects is about .001, the following tables are computed to this grade. Adjustments can be made for other slopes as needed. Table 63, gives the unit streams 1/, required for proper irrigation of the major soil textures with different soil capacities at irrigation time. The infiltration rates and soil intake capacities are taken from field and laboratory data. The typical symbols used on the maps are indicated in the first column. Unit streams less than .001 or over 0.05 are more difficult to manage by surface irrigation and from a practical standpoint should be avoided. Table 64, shows the minimum time of application for different water intake capacities of soils and different unit streams. These are minimum times only. The efficiency with which irrigation is applied will determine the actual irrigation time. Here again irrigation time less than 10 minutes or over 16 hours per border, check or basin becomes a more difficult operation and should be avoided.

(3) Border irrigation - Whether irrigating by borders or border check basins the data in Table 65, will apply. Here for the major soil groups mapped in S. W. Afghanistan are brought together the TRAM (total readily available moisture capacity) and basic intake rates. For these combinations are given the more practical border widths and lengths and border streams for efficient irrigation. Again the time shown is minimum time and will need to be divided by farm irrigation efficiency to obtain total time. The borders are all calculated as multiples or uniform fractions of jiribs to make it easier for computing Afghan farm units and farm delivery requirements, Table 66. Where less than 10 minutes minimum irrigation time is indicated sprinkler irrigation would give better control of water. Where over 16 hours minimum irrigation time is indicated flooding of retaining basins may be the most practical.

These data will help the designer to layout the best system for each land type and still maintain standard sizes suitable for laying out Afghan farm units. The important thing to note here is that a loamy sand soil will require, say a 3 cusec head for a 10 x 100 meter border and 26 minutes minimum irrigation time while a deep silty clay loam may irrigate best on a 15 meter x 300 meter border with a 0.70 cusec head. Large ditches for high heads and short runs must be available to the sandy land farmer, whereas smaller ditches, and longer runs work best for the farmer on the tighter soils.

If proper attention is given to these important soil differences in the layout of farm irrigation systems and if the irrigation water management practices described in this chapter are adhered to much of the present waterlogging and salinizing of lands can be reduced. Water formerly wasted can be used to give more uniform irrigation or extended to new lands. Each acre-foot of water wasted could be worth 15 bushels of wheat or 1,000 Afghanis if made available for plant growth.

1/ Unit stream = head in cfs for land strip 100 feet long and 1 foot wide.

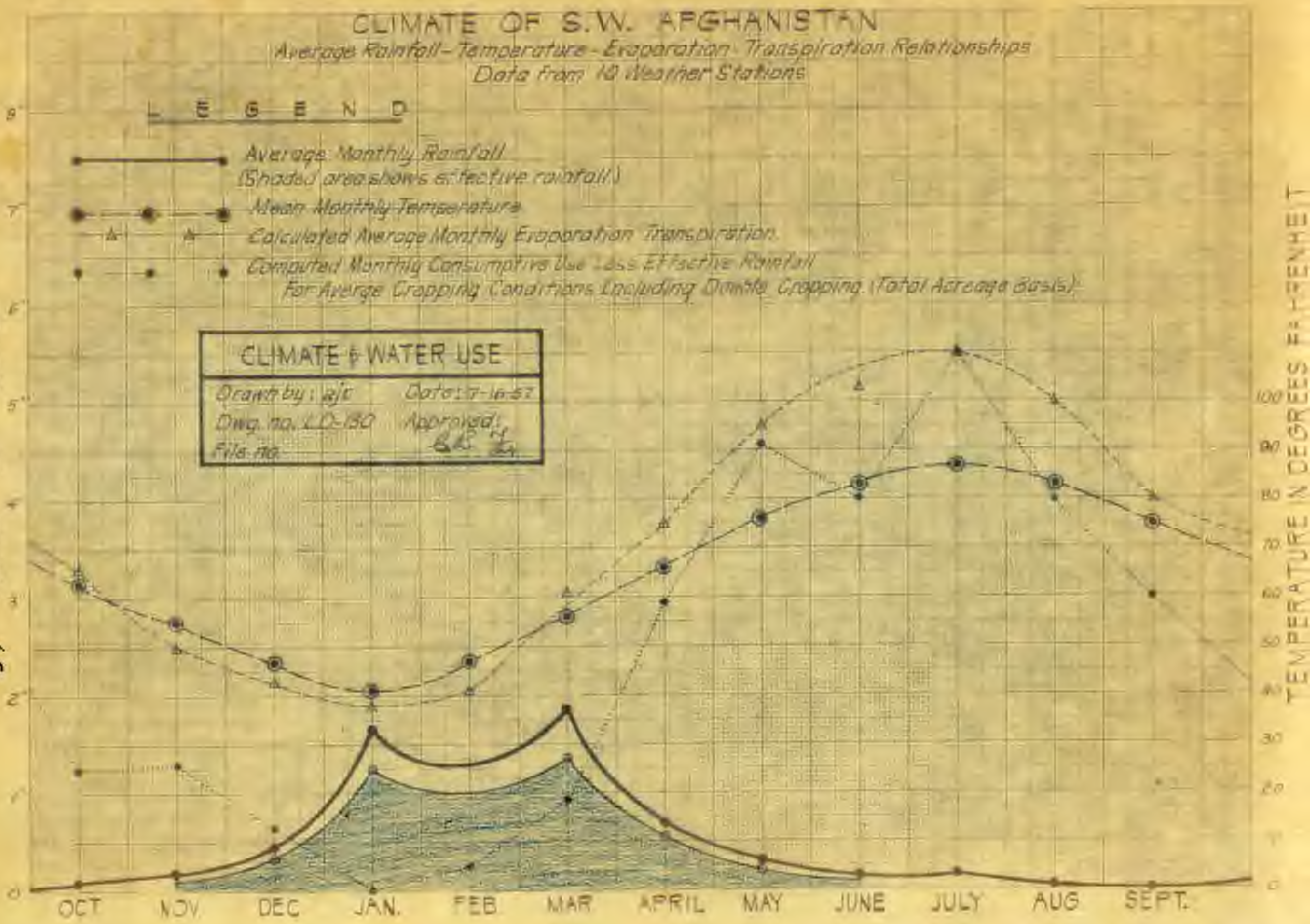

CLIMATE OF S.W. AFGHANISTAN
Average Rainfall - Temperature - Evaporation Transpiration Relationships
Data from 10 Weather Stations
LEGEND
Average Monthly Rainfall
(Shaded area shows effective rainfall)
Mean Monthly Temperature
Calculated Average Monthly Evaporation Transpiration
Computed Monthly Consumptive Use Less Effective Rainfall
For Average Cropping Conditions Including Double Cropping (Total Acreage Basis)
CLIMATE & WATER USE
Drawn by: ajk
Date: 7-16-57
Dwg. no. LD-180
Approved:
File no.
INCHES OF WATER
TEMPERATURE IN DEGREES FAHRENHEIT
OCT
NOV
DEC
JAN.
FEB.
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT.

Table 63

BORDER IRRIGATION TABLES July 14, 1957

Unit Streams for each basic infiltration rate and root zone or
Soil Waterholding Capacity for Slope of .001

[illegible]p [illegible]ymbol	Soils Textural Groups		Basic Intake Rates	TRAM Values or Soil Capacity at Irrigation Time 1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	12"
[illegible]/6	Med. Sands	H	8.0	.2200	.1600	.1160	.0840	.0615	.0470	-----	-----	-----	-----	-----	-----
		A	5.0	.1400	.1015	.0780	.0540	.0425	.0315	-----	-----	-----	-----	-----	-----
		L	3.0	.0834	.0400	.0435	.0330	.0235	.0175	-----	-----	-----	-----	-----	-----
[illegible]/5	Loamy Sands	H	4.0	.1088	.0800	.0580	.0435	.0315	.0235	.0175	-----	-----	-----	-----	-----
		A	2.5	.0690	.0500	.036	.0270	.0195	.0145	.0108	-----	-----	-----	-----	-----
		L	1.5	.0400	.0300	.0220	.0160	.0120	.0088	.0065	-----	-----	-----	-----	-----
[illegible]/4	Sandy Loams	H	2.5	.0690	.0500	.0360	.0270	.0195	.0145	.0108	[illegible]	.0058	-----	-----	-----
		A	1.0	.0270	.0200	.0145	.0110	.0078	.0058	[illegible]	.0032	.0024	-----	-----	-----
		L	.75	.0220	.0145	.1090	.0800	.0058	.0043	.0032	.0023	.0017	-----	-----	-----
[illegible]/3	Med. Texts.	H	1.5	.0400	.0300	.0220	.0160	.0120	.0088	.0065	.0048	.0036	.0026	-----	-----
		A	.50	.0135	.0100	.0073	.0055	.0038	.0029	.0021	.0016	.0012	.0008	-----	-----
		L	.25	.0068	.0050	.0035	.0028	.0020	.0014	.0010	.0008	.0006	.0004	-----	-----
[illegible]/2	Mod. Heavy Textures	H	.50	.0135	.0100	.0073	.0055	.0038	.0029	.0021	.0016	.0012	.0008	.0006	-----
		A	.25	.0068	.0050	.0035	.0028	.0020	.0014	.0010	.0008	.0006	.0004	.0003	-----
		L	.15	.0040	.0029	.0022	.0016	.0015	.0008	.0006	.0004	.0003	.0002	.00017	-----
[illegible] & V/1	Heavy Textures	H	.25	.0068	.0050	.0035	.0028	.0020	.0014	.0010	.0008	.0006	.0004	.0003	.0002
		A	.10	.0027	.0020	.0015	.0011	.0008	.0006	.0004	.0003	.0002	.00016	.0001	.0001
		L	.05	.0013	.0010	.0007	.0006	.0004	.0003	.0002	.00015	.0001	-----	-----	-----
[illegible]V (PS5)	Saline-Alkali Clays	H	.20	.0054	.0040	.0030	.0025	.0016	.0011	.0008	.0006	.0004	.0003	.0002	.0002
		A	.04	.0011	.0080	.0006	.0004	.0003	.0002	.00016	.0001	-----	-----	-----	-----
		L	.02	.0005	.0004	.0003	.0002	.00015	.0001	-----	-----	-----	-----	-----	-----

[illegible] = Average high infiltration values, A = Average and L = Average low values.

TABLE 64

BORDER IRRIGATION TABLES

July 15, 1957

Time to apply various amounts of water with various unit streams *

Unit Stream cfs per 100-ft. long. 1 ft. W.	1" min.	2" min.	3" min.	4" min.	5" min.	6" min.	7" min.	8" min.	9" min.	10" min.	11" min.	12" min.
	Time in minutes and hours											
0.15	0.92	1.84	2.76	3.67	4.59	5.51	6.43	7.35	8.27	9.19	10.10	11.02
0.125	1.19	2.40	3.59	4.79	5.98	7.18	8.38	9.58	10.77	11.97	13.17	14.37
0.10	1.4	2.75	4.13	5.51	6.88	8.26	9.64	11.02	12.4	13.78	15.15	16.53
0.075	1.86	3.72	5.55	7.44	9.18	11.10	13.85	14.9	16.65	18.36	20.46	22.2
0.050	2.76	5.52	8.28	11.04	13.8	16.56	19.32	22.1	24.8	27.6	30.36	33.1
0.025	5.5	11.0	16.50	22.0	27.5	33.0	38.5	44.0	49.5	55.0	1 Hr.	1.1 Hr.
0.0075	18.6	37.2	55.8	1.24 Hrs.	1.55 Hrs	1.86 Hrs	2.17 Hrs	2.48 Hrs	2.79 Hrs	3.1 Hrs.	3.4 Hrs	3.72 "
0.0050	27.6	55.2	1.71 Hrs	1.83 "	2.14 "	3.42 "	3.98 "	3.66 "	4.11 "	4.28 "	4.7 "	6.84 "
0.0025	55.0	1.83 Hrs	2.75 "	3.67 "	4.58 "	5.50 "	6.41 "	7.34 "	8.26 "	9.16 "	10.1 "	11.0 "
0.00075	3.1 Hrs	6.2 "	9.30 "	12.4 "	15.5 "	18.60 "	21.67 "	24.8 "	27.9 "	31.0 "	34.1 "	37.2 "
0.00050	4.6 "	9.2 "	13.8 "	18.4 "	23.0 "	27.6 "	32.15 "	36.8 "	41.4 "	46.0 "	50.6 "	55.2 "
0.00025	9.16 "	18.32 "	27.5 "	36.6 "	45.7 "	55.0 "	64.0 "	73.2 "	82.3 "	91.4 "	100.5 "	110.0 "
0.0001	23 "	46 "	70 "	92.0 "	115 "	140 "	163 "	184 "	207 "	230 "	253 "	280.0 "

* Reference: Agricultural Handbook No. 82, U.S.D.A., SCS, April, 1956.

TABLE 66

July 15, 1957

SUGGESTED PRACTICAL BORDER SIZES FOR AFGHAN FARM UNITS
(Fractions of jiribes) *

BORDER WIDTHS		5 METERS	10 METERS	15 METERS	20 METERS
Border Lengths		Area Jiribes Acres	Area Jiribes Acres	Area Jiribes Acres	Area Jiribes Acres
Meters:					
50	jiribes	1/8	1/4		
	acres	0.06	0.1235	—	—
100	jiribes	1/4	1/2	3/4	
	acres	0.1235	0.247	0.37	—
200	jiribes	1/2	1	1 1/2	
	acres	0.247	0.494	0.741	—
250	jiribes	2/3	1 1/4	1 9/10	2 1/2
	acres	0.309	0.617	0.926	1.235
300	jiribes		1 1/2	2 1/4	3
	acres	—	0.741	1.111	1.482
400	jiribes		2	3	4
	acres	—	0.988	1.482	1.976

* Sandier soils require shorter runs and/or narrow borders, heavier soils can be irrigated with longer runs and wider borders.

CORRUGATIONS AND FURROWS

Each farmer must learn by trial the best layout for his soils. Some general recommendations made by the Soil Conservation Service (U.S.D.A. Leaflet 343, Dec. 1954) are as follows:

	Heavy Soils		Medium Soils		Light Soils	
	Row Length	Furrow Spac.	Row Length	Furrow Spac.	Row Length	Furrow Spac.
Deep-rooted Crops, deep Soils	575 Ft.	24"	425 Ft.	24"	225 Ft.	18"
Shallow-rooted Crops or Shallow Soils	400 Ft.	21"	300 Ft.	21"	150 Ft.	15"

CHAPTER VIII

POTENTIAL AGRICULTURAL DEVELOPMENT AND ECONOMY

Much has already been written about the present and potential production of S. W. Afghanistan. Much more will be written in the future. This is a subject one must approach with temerity since there are no reliable statistics of any sort available to guide such a study. In summarizing the Helmand Valley Surveys, however, the present and potential production and relative costs of development deserve some discussion.

1. Estimates of Past and Present Production.

The 1953 presentation to the Exim Bank placed production prior to any development, 1947 level, at $12,000,000 annually or about 400 million Afghanis at the rate of exchange prevailing then. An October, 1955 report estimated an increase of $4,000,000 (at 21.266 Afghanis = $1.00) in annual income as a result of the development program. In July, 1956, another report summarized the effect of the development program on the increased acreage of lands being farmed each year. It was pointed out that from 1950 to 1956 the increase was 122,000 acres more land in crops each year. Further assumptions as to possible progress were made (Table 67). Applying the same ratio of increased gross production to the 1957 acres as was estimated for 1955 the present annual benefits of the program would be about $5,000,000 annually. The Tudor Commission reported an "average additional gross income in the upper Helmand Valley of nearly $10,000,000 per year". This can hardly be justified as it would require average yields of 21 bushels of wheat per acre on new lands, a jump of 50% in summer crops with an average equal to 27 bushels of corn per acre; and an increase of 7 bushels of wheat per acre on old lands. Tudor then proceeds to state on Page 39, that present wheat yields range from 4-10 bushels (weighted mean of land classes) = 6.8 bushels and corn yields range from 4-15, weighted mean = 8.7 bushels. This hardly bears out the very high annual benefits stated in the preamble of the report.

In none of these former studies had an attempt been made to rationalize the various reports on population, food production, food consumption, imports, exports and wage scales. This was done in Chapter II of this report where it was pointed out that the figure of 3,000,000 population for S. W. Afghanistan cannot be reconciled with known production and land areas. A similar situation was true of livestock population reports. By a series of analyses that correlated the various reports and survey data it was possible to arrive at a population in the entire watershed of 1,500,000. The crop and livestock gross production values were estimated at $24,400,000 and $10,350,000, respectively, or a total gross agricultural production of nearly $35,000,000. The total irrigated land area to reach this production was estimated at 795,000 acres. This would include all lands on the watersheds yielding runoff into the Chakansur-Siestan sinks or about 1/2 of the country. Since the areas used in former reports was principally below the two reservoirs the acreage would be about 48% of the total estimated (Tables 17 & 18) and the proportional gross product about $17,000,000 which correlated with the original production estimate of $12,000,000 and the $5,000,000 increased production due to development.

The annual per capita value of products from these studies was calculated to 985 Afghanis. This is somewhat in line with Tudor's estimate of 1,000 Afghanis for the country as a whole.

2. Surveys of Presently Irrigated and Potentially Irrigable Lands.

As shown in Chapter I, Table 1, about 1,600,000 acres have been surveyed in attempts to locate suitable lands for irrigation. Another 1,500,000 has been examined by rapid, aerial or other methods. The location of areas surveyed, briefly examined or reported are given in Table 68, together with their location, gross acreage, and the presently cultivated and potentially irrigable acreage. Those which have been surveyed are marked by an asterisk. The others have been seen only briefly or are measured from aerial photos.

The 1953 report estimated based on very limited surveys and a rapid aerial reconnaissance of the country that about 820,000 gross acres of irrigable and reclaimable lands lay within command of the Helmand-Arghandab System with 245,000 acres in use at the time. The land classes were estimated at I = 18.8%, II = 23.8%, III = 23.6%, and IV = 33.8%. The latest summary of the 12 projects surveyed indicates 700,000 acres gross irrigable or reclaimable lands with a potential land class distribution of approximately, I = 12.6%, II = 26.1%, III = 49.7%, and IV = 11.6%. The summary of land classes for these areas is given in Table 69.

A map of S. W. Afghanistan projects has been prepared to show all potential land areas of any importance. (Drawing LD-17-R4). The legend shows for each area the potentially irrigable and presently cultivated land, the sources of irrigation water and the relative adequacy of supply. Over 1,155,000 acres are shown as having some agricultural use potential. About 343,000 acres were formerly used for irrigation. Now about 475,000 would be in use within this area.

It can be seen, therefore, that these lands and the Helmand-Arghandab and other streams draining to the Chakansur-Siestan Basin compose a great national resource for Afghanistan. A water resource of 12,000,000 acre-feet annually and a land resource of over one million acres compares with the Columbia River Basin in southwest part of the State of Washington in the United States.

3. Costs of Development.

Again, it must be emphasized that the estimates presented here are not to be assumed as concrete figures for contractual purposes, even though as much data as can be obtained on present and projected costs of development are included. The principal purpose is to provide some sort of yardstick for measuring the total job of land and water resource development, its possible ultimate development cost and to make a comparison of costs with expected returns from agricultural production.

Table 38 presented a summary of land treatment needed by acres for 8 major projects. Table 70 summarizes the estimates made by ACU as to their work and the farmers' contributions. The latest summary of costs was made at the time of the Tudor Commission's short trip to Afghanistan. These figures are presented in Table 71.

May 16, 1957

Table 68

S. W. AFGHANISTAN IRRIGABLE LAND AREAS

AREA NAME	LOCATION (extremes of areas, not meets and bounds) LATITUDE NO.	LONGITUDE EAST	GROSS AREA Acres	CULT. PRIOR TO DEV. PROG. Acres	NET POTENTIALLY IRR. Acres
Arghandab, C.	31° 25' 30" – 31° 42' 50"	65° 13' 50" – 65° 55' 50"	132,220	45,000	80,000
Arghandab, N.	31° 28' 50" – 31° 45' 00"	65° 10' 00" – 65° 45' 00"	67,635	25,000	40,000
Arghandab (Upper)	31° 42' 50" – 31° 48' 00"	65° 42' 50" – 65° 48' 00"	2,000	500	1,000
Arghandab (Lower)	31° 29' 00" – 31° 37' 00"	64° 38' 00" – 65° 13' 00"	20,000	2,000	8,000
Arghastan (Upper)	31° 23' 50" – 33° 00' 00"	65° 54' 00" – 66° 00' 00"	100,000	15,000	60,000
Bakwa	31° 55' 00" – 32° 20' 50"	62° 30' 00" – 63° 15' 00"	350,000	1,000	115,000
Boghra (Nad-i-Ali)	31° 34' 44" – 31° 41' 14"	64° 11' 49" – 64° 18' 47"	25,000	none	18,500
Boghra (Out-of-Proj)	31° 20' 00" – [illegible]	64° 07' 33" – 64° 18' 45"	35,000	none	8,000
Chakansur	30° 32' 00" – 31° 40' 00"	60° 55' 00" – 62° 10' 00"	975,000	40,000	65,000 (250,000)
Darweshan	30° 33' 50" – 31° 09' 34"	63° 50' 00" – 64° 12' 30"	73,910	6,500	45,000
Dori (Upper)	30° 57' 00" – 31° 20' 00"	65° 54' 00" – 66° 45' 00"	50,000	5,000	10,000
Farah (Lower)	31° 23' 00" – 32° 05' 00"	61° 28' 00" – 61° 58' 00"	100,000	7,500	45,000
Farah (Upper)	32° 25' 00" – 33° 15' 00"	62° 10' 00" – 64° 30' 00"	100,000	27,500	50,000
Garmsel	30° 10' 00" – 30° 35' 00"	61° 48' 00" – 63° 50' 00"	123,800	10,000	43,000
Girishk-Shamalan	31° 38' 50" – 31° 50' 00"	64° 08' 24" – 64° 35' 00"	21,000	5,000	12,000
Harut-Adraskand	31° 35' 00" – 33° 55' 00"	61° 10' 00" – 63° 00' 00"	100,000	5,000	45,000
Kajakai-Girishk	31° 50' 00" – 32° 19' 00"	64° 35' 00" – 65° 06' 00"	45,000	12,500	24,500
Kajakai, West	32° 19' 00" – 32° 25' 00"	65° 00' 00" – 65° 06' 00"	12,730	1,550	8,000
Khash	31° 00' 00" – 32° 10' 00"	62° 03' 00" – 63° 25' 00"	250,000	20,000	75,000
Khuspas	31° 20' 00" – 32° 15' 00"	61° 55' 00" – 62° 30' 00"	25,000	500	7,500
Khushk-i-Nakud	31° 35' 00" – 31° 50' 00"	64° 58' 00" – 65° 20' 00"	25,000	4,000	7,500

AREA NAME	LOCATION LATITUDE NO.	 LONGITUDE EAST	GROSS AREA	CULT. PRIOR TO DEV. PROG.	NET POTENTIALLY IRR.
	(extremes of areas, not meets and bounds)		Acres	Acres	Acres
Marja	31° 20' 55" - 31° 31' 41"	64° 02' 11" - 64° 07' 33"	45,000	none	27,000
Musa Qual'eh	32° 06' 00" - 32° 45' 00"	64° 30' 00" - 64° 50' 00"	50,000	10,000	20,000
Miscl. Lands	———	———	———	10,000	75,000
Nauzad	32° 22' 00" - 32° 30' 00"	64° 20' 00" - 64° 32' 00"	20,000	4,500	7,500
Seraj	31° 29' 45" - 32° 02' 30"	64° 21' 21" - 64° 50' 00"	106,000	20,000	60,000
Shamalan	31° 06' 35" - 31° 38' 54"	64° 08' 24" - 64° 21' 42"	65,000	15,000	42,000
Tarnak-Arghastan	31° 21' 50" - 31° 33' 50"	65° 31' 00" - 65° 54' 00"	110,655	15,000	64,000
Tarnak (Upper)	31° 33' 50" - 33° 05' 00"	65° 54' 00" - 68° 00' 00"	———	35,000	95,000
TOTALS	———	———	3,029,750	340,050	1,158,500

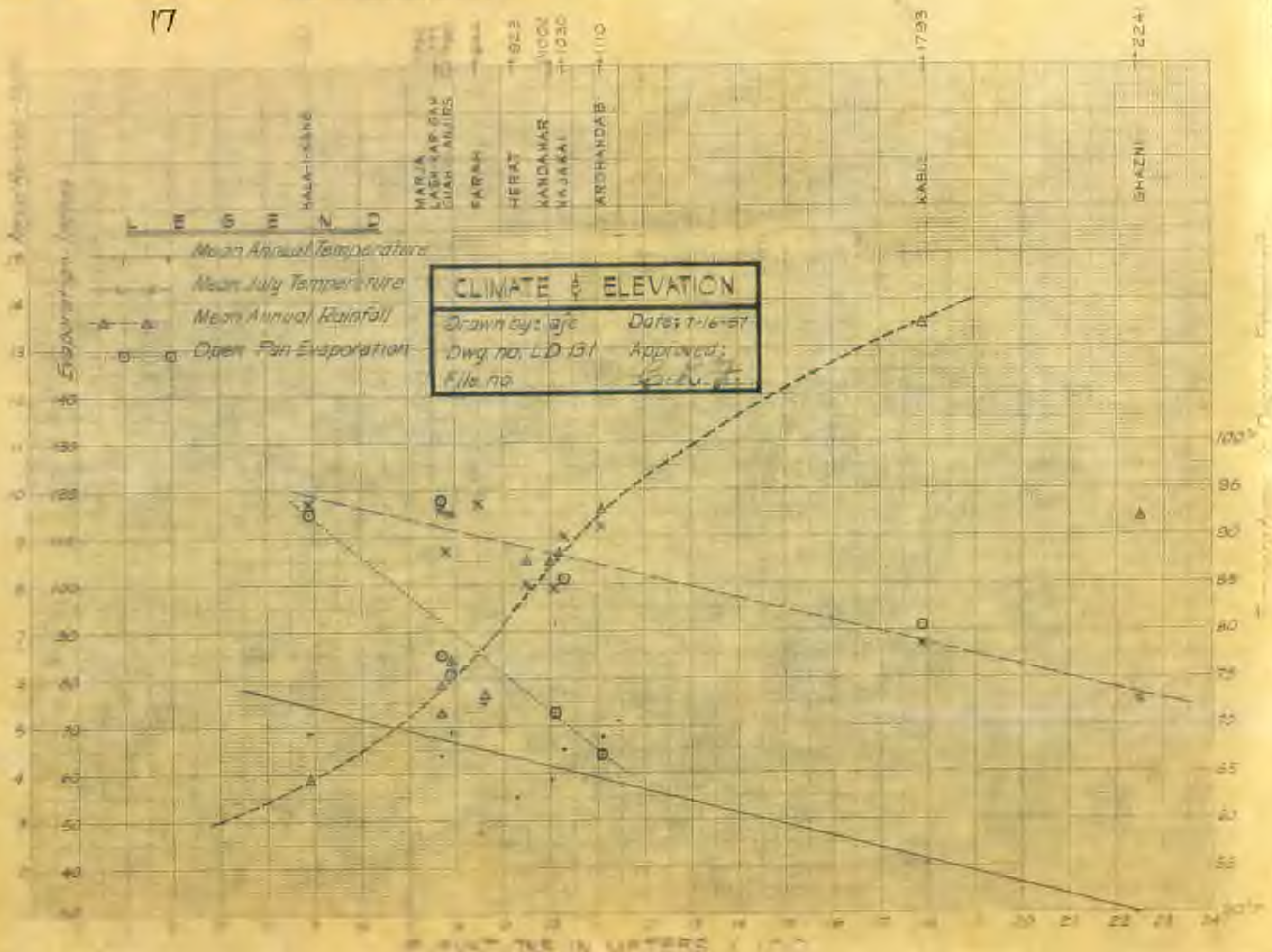
Table 69 SUMMARY OF IRRIGABLE LAND CLASSES - S. W. AFGHANISTAN 8/27/57

Area	Gross Acres in Project	Net Acres Potentially Irrigable				Total Net Irrigable
		Class I	Class II	Class III	Class IV	
Arghandab, C.	132,220	26,048	17,110	37,317	——	80,475 *
Arghandab, N.	67,635	10,208	10,057	16,288	3,680	40,233
Bakwa	350,000	17,250	34,500	46,000	17,250	115,000 *
Boghra	25,000	——	1,531	11,649	5,000	18,180
Chakansur	554,500	——	26,653	69,982	13,365	110,000
Darweshan	73,910	7,492	16,411	21,230	95	45,228
Garmsel	123,800	——	6,038	31,417	4,333	41,788
W. Kajakai	12,780	173	6,790	430	735	8,068
Marja	45,000	——	5,910	7,590	11,500	25,000 *
Seraj	106,000	3,577	10,895	29,692	18,170	62,334
Shamalan	65,000	8,184	10,127	24,064	1,443	43,818
Tarnak	110,655	8,936	29,649	25,768	——	64,353
ALL AREAS		81,695	168,881	320,997	74,836	646,409

* From previous measurements, not latest maps.

Note:

By agreement with HVA Class IV lands in the C. Arghandab and Tarnak were not to be allotted water. Only that annually cropped in N. Arghandab was to receive water. Only the annually cropped acreage for N. Arghandab is shown.


KALA-I-KANG
MARJA
LASH KAR GAH
GIAH ANJIRS
FARAH
HERAT
KANDAHAR
KAJAKAI
ARGHANDAB
KABUL
GHAZNI
1793
2241
923
1002
1030
1110
LEGEND
Mean Annual Temperature
Mean July Temperature
Mean Annual Rainfall
Open Pan Evaporation
CLIMATE & ELEVATION
Drawn by: ajc
Date: 7-16-57
Dwg. no. LD 131
Approved:
File no.
Evaporation, Inches
100
95
90
85
80
75
70
65
60
55
50
ELEVATION IN METERS

8/28/56
By C. P. Swett

Table______

A.C.U. DEVELOPMENT COST ESTIMATES MADE FOR 1956 PROJECTS

Area	Sub-lat. & Accumulator Drains	Farm Ditches	Leveling	Drainage on Farm	Leaching
Darweshan	1,018,290	260,300	2,000,800	1,308,900	44,715
Chamalan	993,600	157,200	1,495,600	1,051,100	86,100
Marja	618,300	266,200	1,099,800	1,583,400	89,000
Nad-i-Ali	———	———	———	2,122,700	56,910
Seraj	1,002,600	432,000	2,268,700	5,000,000	81,300
Tarnak	1,528,900	659,400	1,712,900	3,814,500	108,900
N. Arghandab	560,000	179,635	910,000	1,125,000	123,500
S. Arghandab	1,253,300	400,000	1,200,000	1,262,140	326,600
TOTALS	6,974,990	2,354,735	10,687,700	17,267,740	917,025*

* Leaching work is assumed to be done by the people. It is also assumed they will contribute their own labor to complete checks and borders and level within checks & borders

Some changes have been made in the costs of Tarnak and Nad-i-Ali development, otherwise the data represents roughly what the various interested parties thought the costs were at that time.

While ACU work on farm irrigation and drainage and the peoples contributions to land reclamation reflect some of the jobs to be done in the various projects the data is only relative and may go up or down. Since 130,000 more acres are now annually cropped it is obvious that the farmers are doing a great deal of work themselves. Only 18,300 net in the Nad-i-Ali and some 8,000-10,000 acres in the Marja have been actually prepared to the final stage of cultivation by government and contractual agencies. On the other hand a great stimulus to agriculture in the whole Arghandab-Helmand area was furnished by the installation of the two reservoirs. As previously stated in this report, when the Darweshan diversion and Tarnak siphon are completed major water controls serving 270,000 acres will have been put into effect.

In order to arrive at some basis of allocating costs to various land classes a study of HVA land settlement proposals was made. It was decreed by Kabul that land allotments to settlers would be made on the basis of Class I = 7½ acres or approximately 15 jiribs, II = 10 acres or 20 jiribs, III = 12.5 acres or 25 jiribs, and IV = 15 acres or 30 jiribs. In the Nad-i-Ali the land costs were assessed at 9,000 Afghanis per family, housing at 12,000, livestock and seeds at 5,000 and cash advances at 1,000 Afghanis per family. In the Marja the settlers were assessed 800 Afghanis per jirib of Class II, 600 for Class III, and 400 for Class IV. Loans for housing - 5,000 Afghanis, livestock and farm equipment - 3,000 Afghanis, cash and wheat - 1,000 Afghanis were contemplated. In addition all farmers were to pay 600 Afghanis for water rights and 15 Afghanis annual land tax per jirib. Operation and maintenance charges were to be separate. Table 72 summarizes these development costs which accrue to each farm family as a result of settlement on project lands. These costs are for the most part over and above the construction costs shown in Table 71.

Table 72 PROPOSED DISTRIBUTION OF LAND SETTLEMENT CHARGES TO SETTLERS 8/26/57

Land Class	Annual Land Tax Afs.	Acres Allotted	Land Charge Afs/Acre	Purchase of Water Rights Afs.	Buildings Afs.	Machinery & Livestock Afs.	Seeds & Cash Afs.	Total Afs.	Investment $
I	225	7½	1,000	600	5,000	2,000	1,000	16,100	378.35
II	300	10	800	"	"	3,000	"	17,600	413.60
III	375	12½	600	"	"	3,000	"	17,700	415.95
IV	450	15	400	"	"	8,000	2,000	21,600	507.60

4. Income Potentials and Relation to Costs.

Present income has been discussed above. Present standards of living were discussed in Chapter II. The potential production of these projects depends largely on what the people do under the stimulus of firm water, better irrigation and drainage facilities and governmental and foreign aid. There is a saying,"The more you do for the land the more it will grow for you".

a. Development Stages.

When the program was first outlined in 1953 a series of development stages were contemplated. Four stages of land development, each adding materially to the productive capacity of a given acre of land were assumed to normally occur starting from raw land. These were listed for each project in the 1953 report and an estimate made of the acreage that would reach each stage of development each year. Explanation was given by projects as to the reasons back of the specific estimates made for each. For many reasons few have progressed as anticipated although the benefits to date are not far behind estimates when the land areas improved are considered. Below is a brief discussion of the four stages, necessary in developing the soil and water resources of the area.

Stage 1. A firm water supply with minimum leveling, drainage and conditioning of land. To qualify, the water supply must be adequate throughout the entire year so that crop rotations and double-cropping is possible. In several areas this has now been accomplished, as in the Shamalan, Nad-i-Ali, upper Central Arghandab, and Marja. Tarnak and Darweshan are being ~~prepared~~ for firm water. Improvement in land leveling, drainage, and leaching of salts has made some progress in Marja, Nad-i-Ali, and Shamalan. The farm water distribution system has been improved in Nad-i-Ali and parts of Marja. This work on farm distribution will follow in Tarnak, Central Arghandab and Darweshan when the main canals and laterals have been constructed.

Stage 2. Improved systems of irrigation and drainage should be installed following development of a dependable supply of water. This is necessary to insure proper and efficient use of water. Now where soils and drainage surveys have been made, the main drains can be installed at the time of installing the major irrigation systems. Marja, Nad-i-Ali, Darweshan and Tarnak are following this plan. Land conditioned properly for efficient use in Stage 2, will be cleared of brush and rocks, leveled to insure even water distribution, leached of harmful salts and seeded initially to soil-building crops. Only a few areas in Marja and Shamalan have reached this stage. On-farm drainage will be completed before the land is considered as qualified for the second stage of development. No new land has reached this stage in the Helmand Valley. A few areas in the Shamalan adjacent deep drains are being reclaimed. Substantial increases in crop production per acre will follow the completion of these steps. This stage of development should normally occur within five years after the firm water stage, however, Nad-i-Ali is still little improved after 5 years as far as farm drains are concerned. The use of additional water in some areas may actually result in decreased yields through rising water tables with resultant salinization of the soil. The Nad-i-Ali demonstrates the effect of failure to follow through with farm drains where needed.

Stage 3. Improved crops and land use puts each acre of land to its best use and puts the best variety of each crop on the land. Better seed and crop rotations are real steps forward in production. Improved tillage, planting and harvesting methods will insure better yields. It was predicted in 1953 that within ten years after the firm water stage, on-farm and technical assistance programs should have made marked progress on this phase of improvement. Some work is now being done

along this line by ICA but results so far are limited.

Stage 4. Maximum production can come only after all of the above steps have been thoroughly and efficiently carried through and use of adequate amounts of fertilizers and manures has become an established practice. It was predicted in the 1953 report that after 15-20 years a fertilizer industry might start developing in Afghanistan. It was also predicted that Stage 4, of development might be realized from 15-30 years after the assurance of firm water. The few trials made of fertilizers and green manures have given excellent and promising results. However, large acreages, because of the human factor, may never be developed to their full potential. It appears now that this stage is much farther away than anticipated when the Helmand Valley development program was initiated.

b. Production Potentials and Crop Values.

(1) Crop Production Index.

Studies have been made since 1953 of crop production potentials of various classes of land. There is still very little research on crops, crop management and fertilizer usage in this area. Chapter VI & VII discussed the major problems of irrigation, soil and crop management and fertility. From various sources data has been brought together on the potential production of various crops on the land classes as described in Chapter IV, and the values of these crops based on local surveys of prices as presented in Table 13 of Chapter II. From these a production-value index has been assembled which can be used to quickly evaluate any combination of crops for any land class. Stage 3 level of development is assumed. This represents the maximum development potential without the extensive use of commercial fertilizers. It is quite possible fertilizers will not be available for a long time in large quantities. In fact little value would come from wide use of fertilizers until Stage 3, as described above, has been reached. As of the present then this level should represent the maximum practical attainment of these projects and can be used to evaluate their relative worth as compared to costs of development. Table 73, (3 pages) sets forth the various crops which can be grown, their anticipated yields for different classes of land, the value of the crop in Afghanis per jirib and dollars per acre. As can be seen a wide variety of crops are included. The values also range widely for individual crops depending on the demand for this crop and local market prices. It must be realized of course that demand and price conditions fluctuate widely and that the market possibilities for a given crop should be studied thoroughly before any large production is attempted. In fact, processing centers and markets must be established if more than subsistence agriculture is to result from the Helmand Valley development program. Crops likely to bring higher income and suitable for export include fruits and nuts, tobacco, cotton and wool. Crops of high value locally but probably not suitable for export include potatoes, rice, and certain truck crops. Oil seed crops such as castor bean, cotton for seed, soy bean and peanuts could probably be valuable both for local consumption and for processing to export. The relative values of these are hard to determine. Special crops such as olives, citrus and dates should be studied as to their potential production here. Rice could serve a useful purpose as a reclamation crop on some moderately heavy deep soils and also furnish a highly favored food product now quite high in price compared to other grain crops.

For comparison of crop yields and prices the 3rd page shows yields and values of crops from all U. S. Reclamation projects for the year, 1955, the Columbia Basin yields and prices for the same year and miscellaneous data on yield tests of new varieties and production methods at Nad-i-Ali, Lashkarga and Kabul.

Since these data are averages of all conditions and soil classes they reflect more the expected yields shown for Class III lands. Generally the yields and values used in the crop production - crop value index are about 1/3 to 2/3 those shown as the average of U. S. Reclamation Projects.

(2) Production Potentials of Land Settlement Types of Farms.

The HVA as previously stated set up arbitary limits on land allotments for Classes I-IV. They also recommended certain cropping plans. These are summarized in Table 74, using the crop production index to evaluate gross income. The average per acre returns are Class I - \$109.70, II - \$77.97, III - \$52.73, and IV - \$32.75, @ 42.534 Afghanis = \$1.00. When 35% is deducted for production costs the relative amounts of land to provide equal per capita returns (5 per family) is I - 15 jiribs, II - 21.5 jiribs, III - 33.5 jiribs and, IV - 61.75 jiribs. Classes III & IV require 34% and 106%, respectively, more land per family than the present government allotment allows. This is no doubt a cause for much dissatisfaction among the Nad-i-Ali and Marja settlers. The discrepancy between relative production levels and land allotments was pointed out in 1953 and again in 1954 on both of these projects.

A study of the land settlement allocations and charges as related to repayment and operating costs and net farm family income are shown in Table 75. Part A takes the program as HVA has laid it out but using the production-crop value index and estimating farm production costs at 35% of gross. A much higher livestock purchase is allowed for Class IV land. While the total investment for a Class IV farm is 33% more than for Class I, the net income is less than one-half. Actually since the Class IV land is nearly all in wheat rather than pasture, the cost of operations should be higher making a wider spread between net income levels. It will be noted in part A that total investment per farm is quite low, \$378.75 to \$507.60 or \$50 to \$34 for Classes I-IV, respectively. The benefit:cost ratio expressed in terms of net annual income ÷ total annual costs is high 104:1 for Class I to .875:1 for Class IV. In all cases the O & M costs are figured at \$3.50 per acre-annum and debt retirement @ 4½% for 50 years, regardless of debt. Shorter loans and higher interest rates would of course increase the annual costs.

Part B takes a more realistic approach. It is assumed here that the entire cost of the Helmand Valley program will be chargeable to the land except for a 25% allocation to power which had already been deducted in Table 71. The costs from Table 71, were studied in relation to the percentages of land classes. All projects for which cost estimates are indicated in Table 71, were used. To these were added estimates for the Chakansur (From the Chakansur Report), the Bakwa (at same rate as Chakansur) and Garmsel. All values were weighted and pro-rated to land classes on a percentage basis. High cost projects such as Nad-i-Ali and Marja gave high cost values to Class IV lands. From production tables by land classes a mean value of gross production for each class was determined. These comparative cost and production levels are given in Table 76. To these project construction and land development costs were added the same HVA land allocation and settlement charges as in Part A, except that the basic livestock for Class IV was increased in proportion to the land area.

Table COMPARATIVE PRODUCTION VALUE OF FARM SIZES SUGGESTED BY HVA FOR VARIOUS CLASSES OF LAND 8/27/57
(at full development)

CROPS	CLASS I			CLASS II			CLASS III			CLASS IV		
	Value Jirib	# Jiribs	Total Afs.	Value Jirib	# Jiribs	Total Afs.	Value Jirib	# Jiribs	Total Afs.	Value Jirib	# Jiribs	Total Afs.
Alfalfa	3150	2	6300	2250	4	9000	1800	5	9000	1350	5	6650
Corn	1050	6	6300	900	3	2700	750	5	3700	375	3	1120
Cotton	3000	4	12000	2250	3	6750	1200	4	4800	900	-	-
Garden	3500	0.5	1750	2500	0.5	1250	2000	0.5	1000	1500	0.5	750
Orchard	3750	2	7500	3125	2	6250	2500	1	2500	1250	1	1250
Wheat	1080	-	-	900	7	6400	720	9	6480	540	20	10800
Size & Gross Product		14½*	33850		19.5	32350		24.5	27480		29.5	20570
* House and other buildings and waste land = ½ jirib												
Average Per Jirib	2334	-	-	1659	-	-	1122	-	-	697	-	-
$/Acre	109.70	-	-	77.97	-	-	52.73	-	-	32.75	-	-
Gross Farm Income $ at 42.534 = 1		$795.47			$760.22			$645.78			$483.39	
Per Capita Net Income (Prod. Costs = 35% gross)		$92.85			$86.25			$69.23			$45.10	
Jiribs needed for equal net per capita income		15			21.5			33.5			61.75	

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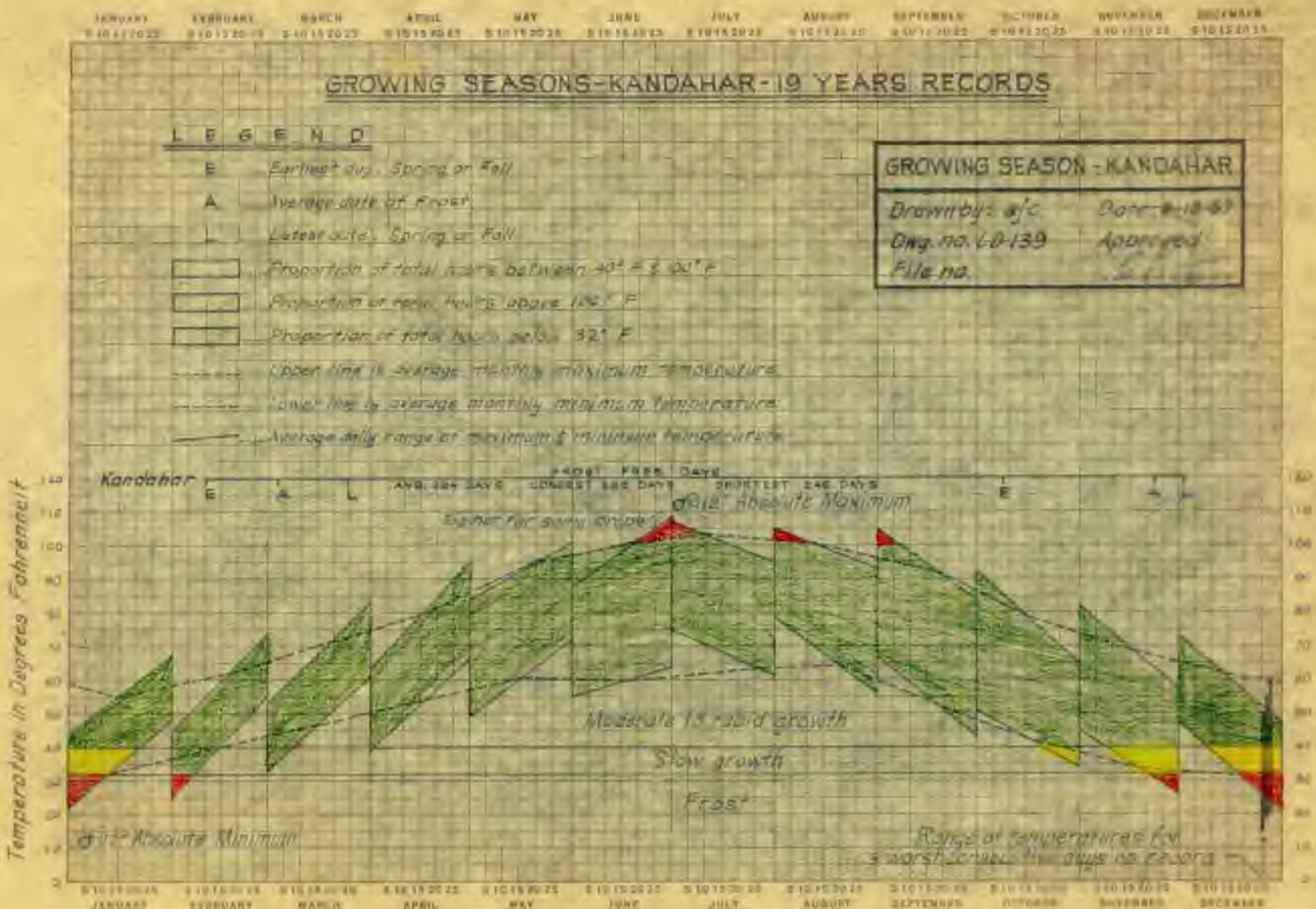
GROWING SEASONS-KANDAHAR-19 YEARS RECORDS
LEGEND
E Earliest day, Spring or Fall
A Average date of Frost
L Latest date, Spring or Fall
Proportion of total hours between 40° F & 90° F
Proportion of total hours below 32° F
GROWING SEASON - KANDAHAR
Drawn by: a/c
Dwg. no. L-D-139
File no.
Approved
Kandahar
E A L
FROST FREE DAYS
AVG. 224 DAYS
LONGEST 256 DAYS
SHORTEST 246 DAYS
Absolute Maximum
Moderate to rapid growth
Slow growth
Frost
Absolute Minimum
Range of temperatures for
Temperature in Degrees Fahrenheit
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

Table 76

ADJUSTED COSTS OF DEVELOPMENT AND GROSS PRODUCTION VALUES BY LAND CLASSES

Class	Per Acre Cost Dollars	Per Acre Cost Afghanis	Per Acre Income Dollars	Per Acre Income Afghanis	Per Jirib Afghanis	Farm Unit Other Costs Afghanis
I	265.00	11,271.15*				
	250.00	10,633.50	225.00	9,570.15	5,785.07	8,600
II	325.00	13,823.55*				
	295.00	12,547.50	160.00	6,805.40	3,402.70	9,600
III	370.00	15,737.58*				
	330.00	14,036.20	85.00	3,615.40	1,807.70	9,600
IV	425.00	18,076.95	47.50	2,020.35	1,010.18	51,600

*Upper number assumes Class IV is not used.

In Chapter II, it was pointed out that a family income of 17,840 Afghanis (see Table 11, would allow a fair standard of living. From this, rental and transportation were deducted as these items would be supplied by other costs already assigned. The study in Part B, resolved itself into determining what farm unit sizes would yield a net family income of 16,500 Afghanis when all costs were allocated against the land. Again O & M was calculated at $3.50 per acre, production costs at 35% and debt retirement (all debts) at 4½% over a 50-year period. Instead of the general cropping program as set up by HVA, however, each land class was assumed to produce the most profitable combination of crops adapted to it. Thus land classes I & II were assumed to have a high percentage of fruits, nuts, cotton, sugar beets and similar crops. Class III was adjusted to general field crops and Class IV to livestock raising with some small grains. (Note: it is doubtful Class IV can yield satisfactorily with only 1/5 land in legumes as shown in Part A).

Part B shows that Classes I & II in high value crops may support twice the number of families shown as the general crop program of Part A. In the long run probably some land will be in each type of crop program. Land Class III acreage remained about the same in Part B, as in Part A. The acreage of Class IV required for a family unit increased to five times that shown in Part A. The reason is obvious in the allocated construction charges and land settlement charges. Class IV land costing $425.00 per acre to develop and requiring a heavy initial investment in legume and grass seeds and livestock becomes a major enterprise to operate on a repayment plan. Even stateside the investment of $32,500 for the 75 acre farm would be considered high. With an investment over 6 times and land area nearly 5 times that shown in Part A as HVA's goal for Class IV the farm fails to meet all expenses and provide the net income of 16,500 Afghanis sought. It is obvious of course that Class IV to be allocated in small holdings can only yield a subsistence income and will not repay the total costs directly allocated on an acreage basis. This does not mean it cannot be utilized for where the irrigation system must cross Class IV land the use of the land for irrigated pasture, hay and small grains is warranted. It does mean however, that the balance of the project must help carry theburden of developing any Class IV lands and that a project largely of Class IV would hardly be suitable for settlement of people in small farm units.

The total farm unit investment, when actual or projected costs are considered range from 3 to 6 times that shown as the Helmand Valley proposal.

It is evident that the land cannot bear these charges in its present condition. Improved irrigation, and production of greater yields of higher value crops must be sought. Processing and marketing must be established. In the period of farm production development the farm people must be given assistance of all kinds. It is obviously to the future advantage of the government to see that this is done. Otherwise these lands will continue at a low level of production and the entire burden of the program must be borne by the government's sources of revenue from other parts of the country.

Part C shows for comparison a similar analyses of the Columbia River Basin Project in the states. The data are taken from various government reports and records. It is apparent that even charging all Helmand Valley development to the farm units they do not reach the proportions indicated for Columbia Basin farms. The Columbia Basin farmer will have invested $45,000-$65,000 in 55 to 120 acre farms. His net income will be $3,270 to $4,144 or average $1,200 per capita. The Afghan farmer will have invested about $2,800 (omitting Class IV) and his per capita net earnings will be about $75.00. The benefit:cost ratios are not far different for Classes I-III. The per capita net income is 7.3% of investment in the Columbia Basin and 13.5% of investment in the Helmand Basin. These comparisons indicate a favorable future provided the many problems facing the valley development are thoughtfully attacked and solved.

5. Overall Helmand Valley Development Costs and Production Potentials.

This is a type of summary that will be misquoted, misused and misunderstood by many. It is well to emphasize now that neither costs nor production values can be guaranteed. Every effort has been made, however, to bring together all the information that will bear on the problem. It will suffice here to say that this total picture is a possible long-time goal toward which the Helmand Valley Authority and its cooperating country and foreign associates may plan and strive.

There are many physical pit falls most of which have been mentioned. The most serious, which have not been treated here, are the human problems. The lack of education among the common people, the low level of living, the antiquated agricultural practices, and the general financial, economic and social situation forces the country to move ahead slowly and carefully. This part of Afghanistan can be made to contribute a substantial part of the nation's wealth, but only by steady, progressive solution of the physical and human problems that now serve to retard. One very small segment of each project if brought to its ultimate development and wisely utilized could spark an interest among farmers and others and help greatly to speed up the agricultural improvement that must follow construction.

Table 77, summarizes the Helmand Valley projects as surveyed under all contracts to date. Some of the final maps are not completed so the picture can change for C. Arghandab, Bakwa and Marja. Drainage, the most serious problem affecting the future of all projects has been investigated in detail only on the two seriously affected desert bench projects, Marja and Nad-i-Ali. Work is progressing in the Darweshan, Shamalan, Tarnak, and Bakwa areas and soon will be initiated in more detail in the Central Arghandab. Without doubt some of these values will change markedly - some for a less favorable, some, we hope, for a more favorable situation.

The benefit:cost ratio as computed compares favorably with that shown for the Columbia Basin Project. Differences in price levels, currency exchange ratios, crop production costs, and developments could easily change the ratios shown and they are submitted only for general study and evaluation purposes.

Table 8/27/57

A SUMMARY OF ESTIMATES OF COSTS, PRODUCTION AT FULL DEVELOPMENT AND BENEFIT:COST RATIOS 2/

Area	Gross Acres	Net Irr. 3/ Acres	Net Acres in Each Land Class I	II	III	IV	Est. Development Cost Total Dollars	Per Acre Dollars	Estimated Production Value Gross Total	Products Per Acre	Net Value Total	Products Per Acre	Total Annual Costs	Benefit: Cost Ratio
1/ C. Arghandab	132,220	80,475	26,048	17,110	37,317	----	12,550,000	155.00	14,800,000	185.0	8,522,800	105.00	6,300,000	1.35:1
N. Arghandab	67,635	40,233	10,208	10,057	16,288	3,680	6,840,000	170.00	5,540,000	137.70	3,315,000	----	2,525,500	1.31:1
1/ Bakwa	350,000	115,000	17,250	34,500	46,000	17,250	50,000,000	500.00	14,000,000	121.70	5,900,000	51.30	8,100,000	0.73:1
Boghra	25,000	18,180	----	1,531	11,649	5,000	7,000,000	385.00	1,470,000	80.30	510,860	27.85	959,150	0.53:1
Chakansur	554,500	110,000	----	26,653	69,982	13,365	55,000,000	500.00	10,840,000	98.50	3,640,000	31.60	7,200,000	0.51:1
Darweshan	73,910	45,228	7,492	16,411	21,230	95	12,500,000	275.00	5,120,000	113.20	2,438,000	53.90	2,682,000	0.91:1
W. Kajakai	12,780	8,068	173	6,790	430	735	2,500,000	300.00	1,500,000	185.90	820,000	101.64	680,000	1.2:1
1/ Marja	45,000	25,000	----	5,910	7,590	11,500	12,000,000	480.00	2,100,000	84.00	635,000	25.40	1,465,000	0.43:1
Seraj	106,000	62,334	3,577	10,895	29,692	18,170	13,215,000	210.00	4,500,000	72.20	1,950,000	31.28	2,550,000	0.76:1
Shamalan	65,000	43,818	8,184	10,127	24,064	1,443	12,000,000	285.00	4,500,000	102.70	2,080,000	47.47	2,420,000	0.86:1
Tarnak	110,655	64,353	8,936	29,649	25,768	----	17,400,000	270.00	11,100,000	172.50	5,960,000	92.60	5,140,000	1.16:1
Garmsel	123,800	41,788	----	6,038	31,417	4,333	8,360,000	200.00	2,500,000	60.00	1,003,000	24.00	1,497,000	0.67:1
TOTALS	1,666,500	646,409	81,695	168,881	320,997	74,836	209,365,000	324.00	77,970,000	120.62	36,774,660	56.89	41,518,650	0.88:1

1/ From previous measurements. Latest maps had not been completed and measured at time of completion of this report. Such changes as may be made will be entered later as a revision of this table.

2/ Costs are taken from previous tables (HVA, ICA, MKA, ACU, estimates); production from land class-production value index at 3rd stage of development; benefit:cost ratio is simple ratio of annual net income divided by annual expenditures.

3/ Data from individual area map measurements reduced 8% for development losses.

The data shows that a total program cost of over 200,000,000 will bring some 646,000 acres into use with an ultimate or potential production value of 78,000,000 annually and a net-benefit of 36,000,000 annually. At the present $5,000,000 in annual benefits from the program are estimated.

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SUMMARY

The Helmand Valley Surveys have covered over 1,500,000 acres of land with soils, drainage, topographic and land use surveys. Agronomic, engineering and economic studies have been made in all or parts of these areas. This report has brought together the basic data on climate, soils and agriculture and discusses the relationships of these to the job of land and water resource development. Supplementary reports for each project summarize the findings as they relate to each project. Maps, soils and drainage logs, laboratory analyses, description of soils as mapped and other pertinent data are assembled as appendices to the project supplemental reports.

- -

CONCLUSIONS

The vast watershed of the Chakansur-Siestan Basin presents opportunities for development of over 1,000,000 acres of irrigated land and 10,000,000 to 12,000,000 annual acre-feet of water. The problems vary from simple to complex. Past use has rendered many tracts of land unproductive because of salinization, water-logging, erosion and other factors. Essentially the job is not one of developing a whole contiguous new block of land but one of reclaiming and rehabilitating a number of widely scattered tracts of badly deteriorated land. It is a challenge to the nation because of the ultimate value of these water resources and land resources involving a gross area of approximately one-half of Afghanistan.

- -

RECOMMENDATIONS

A strong word of caution is offered here. So many times work has been started without adequate information as to its possible outcome or even basic data on which to plan and design a program. These soils and agronomic studies do afford a much sounder basis for planning than before. Nevertheless, they do not give all the answers. Much more needs to be done on drainage, land reclamation, irrigation, water management, processing plants, roads and markets. All of these are vital links to using these soils for successful agriculture. Each in turn presents its own series

of problems and needs careful study.

For the benefit of the Helmand Valley program, particularly future work of HVA, ICA, and ACU, it is recommended that the soils laboratory at Kandahar and at least one experienced soils and agronomy technician be retained in active support of the program. The services rendered will be of extreme value, particularly when land reclamation is contemplated.

APPENDIX I

CLIMATIC TABLES

CLIMATIC TABLES

Summary of climatic data for 10 weather stations in South Afghanistan.

These tables summarize from all sources the existing data pertaining to Climate in this section of Afghanistan.

The records are incomplete and not continuous for some stations. No statement can be made as to reliability of techniques used or records kept. Sources of data include (1) Afghan Meteorological Service, (2) International Cooperation Administration (U.S.A.), (3) Boundary Commission Survey of 1903-1905 and (4) Morrison-Knudsen Afghanistan, Inc.

An attempt has been made to organize the data in a convenient form for study and reference. Crop adaptations and growing seasons, water use requirements of crops have been computed by aid of the information compiled in these tables.

Table 1

CLIMATOLOGICAL SUMMARY

(% Sunshine Hours Same as Kandahar)

7/16/57

Latitude 31° 50' N

Station Arghandab Elev. Meters 1110 Type of (Submerged Pan) Years of
Elev. Feet 3641 Rain Gage Standard Record 1951-1957

Month	Temperature Data: Maximum: Mean	Temperature Data: Maximum: Daily R.	Temperature Data: Minimum: Mean	Temperature Data: Minimum: Daily R.	Mean Mo. Temp.	No. Days 32° F or Less	No. Days 110° or More	Rainfall: Total mm	Rainfall: Total Over 5 mm in 24 hrs. mm	Evaporation: Total mm	Evaporation: Daily Range mm
Jan.	53.6	39-63.7	35.1	24-48.2	44.3	9.7	0	61.7	52.2	54.3	.7-3.5
Feb.	64.3	50-78.1	39.0	30.1-48.5	51.6	3.8	0	47.2	40.0	44.8	.5-2.8
Mar.	74.1	59.3-85.5	47.9	35.1-60.6	61.0	.6	0	49.4	40.4	79.2	1.2-9.4
Apr.	86.2	58.6-99.6	58.0	42.4-57.4	72.1	0	0	13.0	7.5	152.6	2.6-12.8
May	92.6	85.8-107	65.1	57.2-76.2	78.8	0	.8	5.9	0	184.1	4-12.2
June	105.2	88.[illegible]-112.7	70.6	63.2-81	87.9	0	5.0	0	0	218.6	5.5-12.2
July	106.2	97.4-111.6	76.1	68-82.2	91.1	0	9.2	0	0	218.1	5.2-11.6
Aug.	103.0	97-110.2	71.4	63.6-79.8	87.2	0	1.0	0	0	215.3	5.2-11.6
Sept.	97.5	88.2-105	62.8	56-69	80.1	0	0	0	0	163.3	4-9
Oct.	83.1	72.2-90.2	49.4	43.4-65.4	66.2	0	0	0	0	138.4	2.6-7.2
Nov.	73.0	64.8-82.2	42.1	35.2-49.4	57.5	1.0	0	.3	0	92.4	1.4-6.4
Dec.	62.3	49.6-73.6	37.1	28-45.6	49.7	6.6	0	40.0	33.3	60.4	1.3-3.8
Total	1001.1	823.6-1119.4	644.6	546.2-773.3	827.5	21.7	16.0	217.5	173.4	1621.5	34.2-102.5
Annual Mean	83.4	68.6-93.2	53.7	45.5-64.4	68.9	21.7	16.0	217.5	173.4	1621.5	2.8-85.4

Table 2

CLIMATOLOGICAL SUMMARY

7/17/57

Latitude 31° 40' N. Longitude 64° 19' E.

Station Chah-i-Anjirs Elev. Meters 790 Type of Evaporation Pan Years of
Elev. Feet 2591 Rain Gage Standard Ref. Ground Level - 2"-4" Record - Jan. '51 to Dec. '56
(K = .78)

Month	Temperature Data							Rainfall		Evaporation		Rel. Hum. Mean No.	Wind * Velocity Miles Per Hour
	Maximum		Minimum		Mean Mo. Temp.	No. Days 32° F or Less	No. Days 110° or More	Total mm	Total Over 5 mm in 24 hrs. mm	Total mm	Daily Range mm		
	Mean	Daily R.	Mean	Daily R.									
Jan.	57.7	48.5-70	34.0	20-46.6	45.8	11	0	31.4	25.0	47.6	1-12.6	71.0	5.3
Feb.	64.7	51.7-79.1	39.5	28.5-51.1	52.1	5.5	0	31.7	22.0	64.6	.5-3.5	45.7	5.3
Mar.	74.2	47.7-73.3	47.6	26.6-46.2	60.9	1.5	0	38.9	26.0	104.1	2.6-95.7	54.0	6.5
Apr.	89.8	73.2-103.1	60.2	50.4-75.7	75.0	0	0	5.1	4.6	192.3	5.3-10	37.5	7.8
May	100.8	93.7-109.8	67.0	58.2-80.7	83.9	0	2	4.2	0	270.6	10.7-13.8	52.7	6.2
June	106.1	91.5-114.5	72.3	58.6-82.0	89.2	0	6	3.9	0	320.9	9-17	30.2	6.9
July	108.7	104.5-113.0	75.7	66.1-86.8	93.2	0	8	5.0	0	317.9	30-42	32.0	4.3
Aug.	102.5	94.9-109	68.4	60.3-74.3	85.4	0	1	0	0	281.3	23.7-42.4	30.1	3.7
Sept.	97.1	89.3-103.8	58.7	49.5-65.9	77.9	0	0	0	0	207.4	20.6-31.2	32.0	3.7
Oct.	84.9	75.8-92.8	47.9	38.6-56.4	66.4	0	0	1.1	0	122.6	3.3-10.6	43.0	3.2
Nov.	72.8	65-87.8	37.6	35.8-56.3	55.2	2	0	.1	0	87.9	2-8.6	45.7	2.8
Dec.	62.3	54.9-73.8	35.3	22-47	48.8	12	0	14.1	12.0	57.0	1.6-4.3	59.5	3.8
Total	1021.6	890.7-1130.0	644.2	514.6-769.0	832.8	32.4	17	135.5	89.6	2074.2	83.3-291.7	533.4	59.5
Annual Mean	85.1	74.2-94.1	53.6	42.8-64.0	69.4	32	17	135.5	89.6	2074.2	6.9-24.3	44.4%	5.0

* Average of incomplete records from Chah-i-Anjirs, Marja & Lashkarga.

February averaged 9 days and November 8 days. Only 7 days out of a year did the temperatures reach 20° and then only for a very short time. The Central Helmand Area is warmer by 3° or more in December and January and the annual number of days at 32° or below are about one-half the number at Kandahar. The Chakansur-Farah Area averages about 8°-9° higher for December-January and would be expected to have still few days of frost. There is no record of a heavy freeze killing fruit trees in this area. Large sour orange trees and a few date palm have been observed in the City of Kandahar although none have been observed in orchards. Date Palm are noted in the Farah, Darweshan and Garmsel Areas in scattered clumps. No real attempt has been made to grow them for fruit, they appear chiefly used as ornamentals. F. O. Youngs planted a number of seedling oranges and lemons in the Nad-i-Ali Area in 1949. These were growing in 1953 when they were dug up by the Afghans and moved to a very saline and water-logged spot where they subsequently died. Native olive trees grow in abundance in the eastern part of the watershed. Pistachio grows throughout the lower foothill area to the west. It appears from careful comparison of the temperatures and growing conditions of the middle and lower Helmand Areas with more developed areas elsewhere in the world, that a large variety of crops including citrus, dates and olives could be grown if attention was paid to using hardy varieties and root stock. Vegetables are grown year round and cool season legumes and grasses afford year round pasture.

f. General Summary of Climate -

Three graphs serve to present a picture of the general relationships of various climatic factors affecting irrigation development and land use in southwest Afghanistan. Drawing LD-131 shows the comparison of temperature, rainfall and evaporation for the 10 stations studied, arranged in order of elevation. While there is considerable local variation, the general trend seems to hold that higher temperatures, lower rainfall and higher evaporation is encountered as one proceeds from the upper mountain valleys down onto the desert plain and to the lower basins. This relationship is well borne out also by the types and appearance of natural vegetation.

Drawing LD-130 summarizes the relations of rainfall, temperature and evapotranspiration as they affect consumptive use of water by crops. The high demand period for water is April-September inclusive. In January and February as a rule little or no irrigation water is needed. Wheat is grown in places on the winter and early spring rains without benefit of irrigation water. These data are the average of 10 stations. The lower deserts and the Chakansur basin receive very scanty rainfall while dry land crops are regularly grown at the higher elevations.

Drawing LD-139 illustrates the growing season and daily temperature relationships at Kandahar. The daily range of minimum and maximum temperatures may be taken as an indicator of the proportion of hours falling into each bracketed temperature range shown in colors. Thus even in the cooler months a very small proportion of the total hours are below 32° F. Similarly, high temperatures, over 100° F last only a few hours each day from mid-June to mid-August or early September. The nights are generally cool.

I INTRODUCTION:

1. Organization and Plans for Surveys and Reports.

The need for adequate and reliable information regarding the soils and water resources of each potential irrigation project was recognized by the Afghan Government as early as 1946. Frank O. Youngs, then employed by Morrison-Knudsen Afghanistan, Inc., made preliminary soils surveys and investigations of a number of areas in S. W. Afghanistan and reported his findings to the government.

The first organized soils and drainage survey parties were authorized under Supplemental Contract #10 on June 25, 1953. Section I B (1) stated "(the Company) shall make general surveys of---Seraj, Darweshan--Chakansur areas which shall include detail reconnaissance soil surveys-----which will accumulate the necessary information for long range planning of valley development". Section I B (2) states "(company will prepare)....."justification reports of sufficient detail to use as basis for target estimates-----". Section I B (3) states "(company will)...make construction surveys including soil surveys, groundwater and drainage studies---for projects now being prepared for construction---more specifically---Arghandab Valley, Marja and Shamalan areas----".

Supplemental Contract #11 signed in February, 1954, instructed the company to---"continue the engineering and agricultural surveys, investigations and reports, currently proceeding under Supplemental Contract #10-----".

The 1954 Prime Contract signed June 21, 1954, Art. I, Section D, states "-----agricultural surveys----are presently being carried on under another contract. It is intended that this work shall be carried to a certain state of completion more fully described in Exhibit B attached hereto-----" 1. Agricultural Surveys: a. Agricultural Detail Soil Surveys in Tarnak, Arghandab, Seraj, Shamalan and Darweshan areas. b. Agricultural Detail Reconnaissance Soils Surveys in the Seraj and Darweshan Areas. c. Agricultural Ground Water and Drainage Surveys in the Tarnak, Arghandab, Boghra, Marja, Shamalan, Seraj and Darweshan Areas. d. Miscellaneous unspecified work, including but not limited to compilation of data, preparation of reports and general office work relating to the above surveys."

In addition to the authorities given under principal contracts, several out-of-contract and special work orders have been executed. These include:

1. Work Order #29, signed October 28, 1954, authorized detail reconnaissance soils and drainage surveys of the Chakansur, Rud-i-Biyaban and Garmsel areas in addition to certain engineering studies.

2. Work Order #38, signed 3/8/55 authorized detail-reconnaissance soils and drainage surveys and certain engineering surveys of Bakwa, Khash, and Farah areas. By letter 421/242 of 5/9/55, the Musa Kala area was added to this list.

3. A.C.U. Work Order #5, was amended by letters ACUP-3-40, ACUP-3-50 and ACUP-3-54 to provide for very detailed soils investigations of certain blocks and subblocks in the Marja project.

Table 3

CLIMATOLOGICAL SUMMARY

7/16/57

Latitude 32° 10' N. Longitude 62° 00' E.

Station FARAH Elev. Meters 844.2 Type of Years of
Elev. Feet 2900 Rain Gage Standard Record 1944-1946

Month	Temperature Data: Maximum Mean	Maximum Extremes	Minimum Mean	Minimum Extremes	Mean Mo. Temp.	Rainfall Total mm	Wind Velocity Miles Per Hour
Jan.	62.9		41.7	17 1/10/45	52.3	26.5	
Feb.	75.0		40.6	27 2/8/45	57.8	23.4	
Mar.	87.7		47.7		67.7	10.5	
Apr.	89.2		55.2		72.2	1.0	
May	99.3		64.9		82.1	1.3	
June	104.4		69.3		86.8	0.0	NO DATA
July	106.9	115 7/6/44	80.6		93.7	T	
Aug.	103.6	112 8/22/45	71.1		87.3	0.0	
Sept.	95.4	115 9/14/45	60.3		77.8	0.0	
Oct.	86.4		49.6		68.0	T	
Nov.	81.7		50.9		66.3	15.0	
Dec.	70.7		47.3	14 12/21/45	59.0	40.0	
Total	1063.2		679.2		871.0	117.7	
Annual Mean	88.6		56.6		72.4	4.6"	

Table 4

CLIMATOLOGICAL SUMMARY

7/16/57

Latitude 33° 30' N. Longitude 68° 20' E.

Station GHAZNI Elev. Meters 2240.9 Type of Years of
Elev. Feet 7350 Rain Gage Standard Record 1944-1947

Month	Temperature Data: Maximum Mean	Temperature Data: Minimum Mean	Temperature Data: Mean Mo.	Rainfall Total mm	Relative Humidity Mean * Monthly	Wind Velocity Miles Per Hour
Jan.	32.9	10.4	21.6	41.5	70.3	3.81
Feb.	33.6	11.7	22.6	40.7	74.6	6.27
Mar.	39.6	28.2	33.9	52.7	65.3	5.60
Apr.	52.9	38.7	45.8	21.7	47.6	8.29
May	72.7	43.5	58.1	27.0	47.0	7.39
June	84.0	45.3	64.6	9.2	33.0	6.05
July	88.5	56.3	72.4	11.2	45.0	6.50
Aug.	103.1	55.4	79.2	2.0	49.3	6.27
Sept.	81.9	45.0	63.4	2.4	41.0	5.60
Oct.	69.3	34.5	51.9	0.0	37.6	7.17
Nov.	51.4	31.1	41.2	2.1	49.0	5.82
Dec.	46.6	37.8	42.2	12.5	66.6	7.17
Total	756.5	437.9	597.2	214.0	626.3	75.94
Annual Mean	63.0	36.49	49.77	8.4 (in.)	52.2 %	6.33

* Average of 7:00 A. M., 1:00 P. M. & 9:00 P. M. readings.

Table 5

CLIMATOLOGICAL SUMMARY

7/16/57

Latitude 34° 20' N. Longitude 62° 10' E

Station HERAT Elev. Meters 922.6 Elev. Feet 3026 Type of Rain Gage Standard Years of Record 1941-1948

Month	Temperature Data: Maximum Mean	Maximum Extremes	Minimum Mean	Minimum Extremes	Mean Mo. Temp.	Rainfall Total mm	Wind Velocity Miles Per Hour
Jan.	50.0		30.9	0.5° 1/19/43	40.4	62.0	9.6
Feb.	54.3		33.8	13° 2/3/43	44.5	33.3	8.1
Mar.	64.0		40.8	23° 3/9/48	52.4	38.7	8.7
Apr.	77.7		47.7	26° 4/1/45	62.7	8.7	8.5
May	87.3	102° 5/2/44	56.1		71.7	4.3	8.1
June	93.6	104° 6/26/45	64.4		79.0	0.0	11.6
July	97.3	110° 7/8/46	72.3		84.8	T	14.8
Aug.	94.5	108° 8/1/41	70.5		82.5	0.0	17.7
Sept.	90.1	103° 9/5/48	56.3		73.2	0.0	11.6
Oct.	81.1		44.4	28° 10/27/45	62.7	T	6.5
Nov.	66.9		35.4		51.1	7.9	6.3
Dec.	51.1		32.2	-7° 12/21/48	41.6	33.7	6.0
Total	907.9		584.8		746.6	188.6	117.5
Annual Mean	75.65		48.73		62.2	7.43"	9.8

6 7

Table ______ CLIMATOLOGICAL SUMMARY 7/16/57

Latitude 34° 10' N. Longitude 69° 10' E

Station Kabul Elev. Meters 1792.7 Type of Years of
Elev. Feet 5880 Rain Gage Standard Record 30

Month	Temperature Data % Sunshine Hours	Mean Mo. Temp.	Rainfall Total mm	Evap. Total mm	Wind Velocity Miles Per Hour
Jan.	7.06	32.00	30.7	48	2.69
Feb.	6.90	31.28	36.3	69	3.36
Mar.	8.36	43.52	102.9	116	3.52
Apr.	8.81	53.96	93.2	169	3.02
May	9.75	65.30	19.8	230	3.09
June	9.74	73.76	5.3	328	3.81
July	9.91	78.26	3.3	396	4.29
Aug.	9.35	74.84	3.5	300	3.07
Sept.	8.36	66.92	0.3	304	3.29
Oct.	7.89	55.22	14.2	173	2.15
Nov.	6.99	44.96	20.8	117	1.70
Dec.	6.88	34.70	10.9	55	1.84
Total	100.00	654.72	341.2	2305	36.13
Annual Mean		54.56°	13.5" *	90.75"	3.1

* A 30-Year Average (ICA report shows 13.4" Average).

1

4

Table ________

CLIMATOLOGICAL SUMMARY
(% Sunshine Hours Same as Bakwa)

7/17/57

Latitude 32° 20' N.

Station Kajakai Elev. Meters 1030 Type of Rain Gage Standard Evaporation Pan Ref. Ground Level ± 0 Years of Record 1951-1957

	Temperature Data							Rainfall		Evaporation	
	Maximum		Minimum		Mean No. Temp.	No. Days 32° F or Less	No. Days 110° or More	Total mm	Total Over 5 mm in 24 hrs. mm	Total mm	Daily Range mm
Month	Mean	Daily R.	Mean	Daily R.							
Jan.	55.8	45.1-67.5	35.8	26-46.6	45.8	10.1	0	36.6	29.6	31.3	.3-3.3
Feb.	65.3	49.6-76.1	39.5	30.8-52.8	52.4	6.7	0	35.2	22.4	84.3	13-28.8
Mar.	73.7	62.3-82.6	46.8	35.8-58.1	60.2	2.3	0	73.1	59.4	100.3	3.2-11
Apr.	85.8	68.3-97	53.9	44.5-65.5	69.9	0	0	14.5	13.1	203.3	5.7-20.2
May	98.7	86.4-106.4	61.7	51-73.4	80.2	0	4.0	2.9	0	329.0	8.2-29.2
June	105.3	95.2-113.2	68.0	58.2-82.2	86.6	0	8.7	.01	0	387.7	8.3-27.2
July	107.5	99-114.4	73.0	64.2-83	90.2	0	14.2	3.6	2.3	392.5	5-24
Aug.	103.0	93.4-112.4	54.9	58.2-76.6	78.9	0	4.6	0	0	362.7	9.5-22.2
Sept.	96.1	85.4-105.4	55.6	48-63.2	75.8	0	2.0	0	0	286.7	7.2-19.5
Oct.	83.1	70.6-91.4	44.7	36.6-56.4	63.9	0	0	.5	0	198.5	6-15
Nov.	75.1	63.6-101.4	37.5	30.1-48.3	56.2	4.2	0	.1	0	112.2	4.4-13
Dec.	63.6	50.5-75.1	36.7	24.6-48.3	50.1	12.1	0	29.6	27.2	83.2	3-7.6
Total	1013.0	869.4-1142.9	608.1	508-754.4	810.0	35.4	33.5	196.11	154.0	2571.7	62.1-221
Annual Mean	84.4	72.5-95.2	50.6	42.3-62.8	67.5	35	34	196.11 7.72"	154.0 6.06"	2572 101"	5.1-18.4

9

Table______

CLIMATOLOGICAL SUMMARY

7/16/57

Latitude 30° 32' – 31° 40' N
Longitude 60° 55' – 62° 10' E

Station Kali-Kang Chakansur — Elev. Meters 490, Elev. Feet 1607 — Type of Rain Gage Standard — Evaporation Pan Ref. Ground Level ± Open Pan (at ground level) — Years of Record: 1903–1905, 1952–1953, 1955–1956, 6 Partial Yrs.

Month	Maximum Mean	Minimum Mean	% Sunshine Hours	Mean Mo. Temp.	No. days 32° F or Less	No. days 110° or More	Rainfall Total mm	Evap. Total mm	Relative Humidity Mean Monthly	Wind Velocity Miles Per Hour
Jan.	55.9	31.5	7.250	43.7	15		25.40	66.29	53	6.5
Feb.	66.3	35.6	7.000	50.9	8		20.30	90.42	45	8.0
Mar.	71.9	44.8	8.375	58.3	3		15.25	115.32	52	8.5
Apr.	88.8	55.5	8.735	72.1		5	5.10	176.02	45	7.5
May	101.2	65.1	9.580	83.2		12	T	287.02	37	8.5
June	107.2	70.4	9.545	88.8		18	0.0	483.87	27	12.0
July	107.3	76.9	9.720	93.0		22	T	520.70	30	15.0
Aug.	102.6	72.5	9.250	87.6		18	0.0	411.48	22	15.0
Sept.	94.5	61.1	8.340	77.8			0.0	320.80	37	10.0
Oct.	87.2	46.1	7.960	66.7	1		0.0	216.66	43	6.5
Nov.	78.6	39.1	7.150	58.9	3		T	139.70	50	4.5
Dec.	65.5	33.5	7.095	49.9	12		6.35	95.25	54	4.5
Total	1027.0	632.1	100.000	830.9	42	75	72.40	2923.54	495	106.5
Annual Mean	85.58	52.57	—	69.2	42	75	72.40 2.85"	2923.54 115.10"	41% (1956 Only)	8.9 *

* Wind velocities taken from partial records MKA, 1953, ICA, 1956, & British Survey of 1904.

Table______ CLIMATOLOGICAL SUMMARY 7/17/57

Latitude 31° 34' 12" N
Longitude 64° 21' 22" E

Station Lashkargah Elev. Meters 775 — Type of Rain Gage Standard — Evaporation Pan Ref. Ground Level ≠ 0 (K = .70) — Years of Record – Jan.'54 to May '57

Month	Temperature Data					Rainfall Total mm	Evap. Total mm	Relative Humidity Mean Monthly	Wind * Velocity Miles Per Hour
	Maximum		Minimum		Mean Mo. Temp.				
	Mean	Daily R.	Mean	Daily R.					
Jan.	56.6	67.1-46.1	35.5	42.8-28.2	46.5	18.0	63.0	64.0	2.7
Feb.	66.6	74.1-59.1	35.5	41.9-29.1	51.5	26.2	91.4	53.5	.2
Mar.	74.1	81.9-66.3	48.5	59.8-37.2	61.3	36.4	155.7	63.5	5.1
Apr.	75.1	98.3-51.9	38.7	35.3-42.1	56.9	6.8	243.0	52.0	9.5
May	96.7	112.1-81.3	62.3	71.2-53.4	79.5	0	390.3	28.5	3.3
June	102.2	114.4-90.0	67.8	74.4-61.2	85.0	0	233.6	30.0	6.1
July	104.3	110.9-97.7	73.7	86.5-60.9	89.0	0	290.2	41.5	3.8
Aug.	102.7	108.0-97.4	68.5	73.8-63.2	85.6	0	266.0	26.5	2.7
Sept.	96.3	102.9-89.7	58.5	67.4-49.6	77.4	0	182.8	37.5	3.7
Oct.	81.5	87.8-75.2	44.3	50.8-37.8	62.9	3.0	96.6	37.0	2.4
Nov.	74.0	81.1-66.9	39.3	46.8-31.8	56.6	.3	81.0	36.0	4.6
Dec.	61.5	79.9-43.1	34.3	45.5-23.1	47.9	21.1	50.8	55.2	5.2
Total	991.6	1118.5-867.7	606.9	696.2-517.6	800.1	111.8	2144.4	525.2	49.3
Annual Mean	82.4	93.2-(71.6)	50.5	57.9-43.1	66.6	111.8	2144.4	43.8%	4.1

* Average of incomplete records from Lashkargah, Marja & Chah-i-Anjirs.

Table 10

11

CLIMATOLOGICAL SUMMARY

?/?7/57

Longitude 31° 30' N. Latitude 65° 40' E — Kandahar, A[illegible]ghanistan

Station Mansal Bagh Elev. Meters 1002.5 Elev. Feet 3288 Type of Rain Gage Standard Evaporation Pan 0" to Ref. Ground Level -6" Years of Record 1939-1957

Month	Temperature Data: Maximum (Extreme = 112°) Mean	Maximum Daily R.	Minimum (Extreme = 12°) Mean	Minimum Daily R.	Mean Mo. Temp.	No. nights* 32° F or Less	No. nights* 20° F or Less	No. days 110° or More	Rainfall: Total mm	Rainfall: Total Over 5 mm in 24 hrs. mm	Surface pan free water Evaporation: Total mm	Evaporation: Daily Range mm	Per[illegible] Re[illegible] Hu[illegible] 19[illegible]-1950 Mea[illegible] Mo[illegible]ly	Mean Daily Range	Wind Veloc. (est) Miles Per Hour	% Total Sunshine Hours
Jan.	55.4	44-67	32.3	22-43	44.0	17.3	2	0	66.60	52.5	43.9	.3-2	61[illegible]0	26-70	4.0	7.220
Feb.	62.4	65-74	40.3	25-55	48.7	9.0	2	0	44.20	31.8	65.3	1-3	57[illegible]8	27-67	4.2	6.990
Mar.	71.4	53-83	46.5	33-61	57.3	1.2	0	0	35.60	31.1	96.3	1-5	[illegible]	21-56	4.5	8.370
Apr.	83.6	63-95	53.9	39-66	67.1	0	0	0	11.80	7.9	165.9	2-9	[illegible]	18-63	5.0	8.740
May	94.5	84-101	61.4	49-72	75.9	0	0	0	5.67	1.0	228.8	6-7	[illegible]	17-53	4.0	9.600
June	101.2	88-109	66.05	55-64	81.1	0	0	4	0.15	0	256.0	8-10	[illegible]	22-48	4.5	9.570
July	104.3	95-107	63.0	61-75	84.7	0	0	3	3.50	1.3	273.1	5-9	[illegible]	14-50	5.5	9.245
Aug.	100.3	93-105	64.5	56-79	81.6	0	0	1	0.06	0	260.1	7-13	[illegible]	12-48	3.5	9.270
Sept.	92.0	94-105	52.5	43-67	72.9	0	0	0	0.00	0	191.5	5-11	[illegible]	12-48	2.5	9.340
Oct.	79.2	65-92	42.0	34-51	63.6	2	0	0	0.15	0	132.8	2-6	[illegible]	19-56	2.0	7.950
Nov.	69.1	57-82	34.1	26-45	53.5	8.4	0	0	1.31	.4	79.5	1-5	[illegible]	23-67	2.0	7.130
Dec.	61.7	48-73	30.8	21-47	45.6	15.2	3	0	19.10	11.5	48.3	1-2	54[illegible]2	22-76	2.5	7.080
Total	975.1	829-1093	587.3	464-730	716.0	—	-	-	—	—	—	39.3-82	[illegible]	273-704	44.2	100.00
Annual Mean	81.2	69-91	48.9	39-61	64.6	53.	7	8	188.14	137.5	1843.5	3-7	[illegible]	20-60	3.7 mph	—

* No full 24 hour days have been below 32° F.

Table 11

CLIMATOLOGICAL SUMMARY

7/17/57

Latitude 31° 25' N to 31° 40' N; 64° 15' E

Station Marja Elev. Meters 765 Type of Evaporation Pan Years
Elev. Feet 2510 Rain Gage Standard Ref. Ground Level + 2" of Record – Jan. 1954 to Mar. 1957

Month	Temperature Data: Maximum Mean	Temperature Data: Maximum Daily R.	Temperature Data: Minimum Mean	Temperature Data: Minimum Daily R.	Mean Mo. Temp.	No. Days 30° F or Less	No. Days 110° or More	Rainfall Total mm	Rainfall Total Over 5 mm in 24 hrs. mm	Evaporation Total mm	Evaporation Daily Range mm	Wind * Vel. Miles Per Hour
Jan.	59.3	52-71	34.6	27.5-47	46.7	10.5	0	41.4	32.2	65.9	1.6-7	4.9
Feb.	66.7	54.5-79.5	39.9	27.6-51.6	53.3	4	0	10.1	4.3	119.0	1-9.6	5.3
Mar.	73.8	59.5-83	51.3	40-60	62.5	0	0	40.3	35.2	172.0	1-12	5.7
Apr.	86.5	67-97	59.5	44.5-68.5	73.0	0	0	4.8	—	203.2	3.5-15.5	8.5
May	100.0	88-109.5	67.7	60-77.5	83.8	0	6.5	0	0	381.4	6.5-21.5	5.8
June	103.5	96-111.5	72.0	63.5-82	87.7	0	4	0	0	397.8	10.5-19	6.5
July	106.5	95.5-112.5	79.5	72-85	93.0	0	8	0	0	463.0	10.5-18.5	4.0
Aug.	103.0	93-111	71.5	67-83	87.2	0	1	00	0	437.8	10.5-20	3.8
Sept.	97.9	87-103	63.3	58-72	80.6	0	0	0	0	278.1	8.5-16.5	3.7
Oct.	83.5	72-95	49.2	45-66	66.3	0	0	0	0	203.5	5-14.5	3.3
Nov.	74.5	64-82.5	42.5	36.5-50.5	58.5	0	0	0	0	166.0	4-9	3.6
Dec.	61.3	47-72	37.3	28-48	49.3	6	0	27.7	0	94.8	1-5.5	4.3
Total	1019.3	875.5-1127.5	668.3	569.6-791.1	841.9	20.5	19.5	124.3	71.7	2982.5	63.6-168.6	59.4
Annual Mean	84.9	72.9-93.9	55.6	47.4-65.9	70.1	21	20	124.3	71.7	2983	5.3-14	5.0

* Average of Chah-i-Anjira, Nad-i-Ali, Lashkargah & Marja – all incomplete records from 1951-57.

APPENDIX II

ANALYSES OF GROUND WATER

3. Native Vegetation.

Very little data is available on the flora of Southwest Afghanistan. Some published literature in German covers parts of the area but is unavailable for this report. From such preliminary reports as are at hand and general notes made of vegetation over the area the following describes the relation of plant distribution, soils and climatic situations in the watershed.

Roughly the watershed may be divided into four broad divisions: (1) the lower desert plains, basins and valleys, (2) the central to upper gravelly outwash desert, river valleys and old high terraces, (3) the "Registan" or sand dune area chiefly south of the Arghandab and Helmand Rivers, and (4) the lower foothills and mountains with their valleys and narrow fans and talus slopes. A fifth division would include the high valleys and mountains where some forest types exist.

Within each of these certain vegetative types and associations are noticed. The lower deserts from about 700 meters down into the lowest basins at 400 meters present a generally barren appearance except for soil situations more favorable to plant growth. One may drive across the vast Dasht-i-Margo between June and December and see only a few small scattered communities of low shrubs in sand covered depressions. In the early spring after a series of rains short grasses, flowering shrubs, and low plants, including numerous low or creeping legumes, seem to literally spring out of the ground and more favored spots resemble miniature flower gardens. With the first high temperatures of summer, however, the green landscape is quickly reduced to its typical desolate appearance with the sun-blackened, glistening gravels constituting the principal cover. Only the river valleys and the marshes of the basins bear much vegetation. Depth to ground water, soil texture and degree of salinity largely control the species on each site. The sandy flood plains and stabilized river wash areas are covered chiefly with tamarisk and occasional clumps of tall grasses. Next to the stream beds are willows, ash, sedges and giant reed grass. The deep alluvial and lake basin soils which are free of salts or only slightly saline are covered by small thorny shrubs such as a mimosa, and camelthorn, and tall coarse grasses such as the panic grasses, love grasses and a wild rye grass. The severely saline areas having a water table within 2-5 meters are usually covered with a coarse grass having a tough heavily sheathed tap root. This is a phreatophyte, feeding on the capillary fringe above the water table it is able to exist in an area having very high salts at the surface. Locally all these grasses are referred to as "jarru". They support some grazing in the late winter to early summer but become too coarse in full growth to be palatable. Extremely saline areas having no or a deep water table are generally barren or scantily covered with salt weeds, generally the Chenopodiacea, such as clumps of salsola and halogeton-like plants. The hard-packed silty clay soils of the Chakansur Basin are smooth and completely barren over great stretches. The high actively shifting sand dunes also are generally barren. Over 200,000 acres of such dunes have collected in the southeast part of the Chakansur Basin. Hundreds of square miles of moving dunes occur on the desolate stretches of the "Registan", a vast territory lying between the desert plains and the low mountain ranges of Baluchistan. Numerous unidentified grasses and shrubs are growing on the lower, less active sands.

The central and upper desert fans and river valleys have similar species but, with more favorable rainfall and slightly cooler seasons, have maintained a semblance of grazing lands in spite of heavy usage. The deep and less saline soils are characterized by numerous shrubs and forbs such as artemisia, camelthorn, and dwarf mimosas. The taller more palatable grasses have been pretty well destroyed by hundreds of years of grazing by sheep and goats but stipa, aristida and brome grasses are found. Bulbous blue grass is seen in abundance in the early spring. Dozens of unclassified vetches, clovers and other legumes appear in the early spring

Table_______ **GROUND WATER ANALYSIS REPORT** 7/30/57

	CENTRAL ARGHANDAB AREA						NORTH ARGHANDAB AREA	
	Kandahar Art. Well	Diversion Dam	Manzel Bagh Wells		Artesian		Well Nos.	
Location	Approx. 185'	Well	#1	#4	215 Ft.	24A	33	104
Conductivity:								
$ECx10^6$ @ 25° C	2046	800	903	1400	2499	301	647	1267
% Na	63	41	43	29	54	13	26	34
pH	7.8	7.6	7.4	7.3	7.4	7.4	7.6	7.3
Dissolved Solids:								
ppm Salt 1/	1387	569	638	1101	1534	253	554	1060
tons/A. F. 2/	1.9	.77	.87	1.50	2.09	.33	.75	1.44
S.A.R:	5.5	2.7	2.5	2.0	5.7	.60	1.1	2.2
Irrigation Classif:	C3-S2 4/	C3-S1	C3-S1	C3-S1	C4-S2	C2-S1	C2-S1	C3-S1
Cations me/1:								
Ca	2.52	2.64	3.51	6.08	4.36	1.64	2.77	3.12
Mg	5.73	3.15	1.97	5.72	6.69	1.19	2.26	6.12
Na	13.56	4.04	4.03	4.84	13.50	.44	1.84	4.84
K	.2	.08	.03	.04	.20	.06	.10	.04
SUM	21.71	9.91	9.98	16.68	24.72	3.33	6.97	14.12
Anions me/1:								
CO_3	0	.10	0	0	0	0	0	0
HCO_3	4.15	4.40	3.11	4.35	3.11	2.68	5.50	11.05
Cl	9.66	1.33	1.32	9.30	13.28	.45	.60	1.80
SO_4 3/	7.90	4.08	5.28	3.03	8.33	.20	.87	1.27
SUM	21.71	9.91	9.71	16.68	24.72	3.33	6.97	14.12
Number of Samples:	4	1	4	1	5	1	1	1

1/ Dissolved Solids (ppm) calculated from me/1 x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

Table 2

GROUND WATER ANALYSIS REPORT

7/30/57

DARWESHAN AREA

Location	Old Well	MKA Well
Conductivity:		
$ECx10^6$ @ 25° C	1500	3400
% Na	51	60
pH	7.4	7.1
Dissolved Solids:		
ppm Salt 1/	1065	2728
Tons/A. F. 2/	1.45	3.7
S.A.R:	4.2	8.0
Irrigation Classification:	C3-S1 4/	C4-S2
Cations me/1:		
Ca	3.00	6.15
Mg	4.34	10.65
Na	7.92	23.90
K	.16	.30
SUM	15.42	41.00
Anions me/1:		
CO_3	0	0
HCO_3	6.42	10.00
Cl	3.33	12.30
SO_4 3/	5.68	18.70
SUM	15.43	41.00
Number of Samples	2	1

1/ Dissolved Solids (ppm) calculated from me/1 x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

Table 3 **GROUND WATER ANALYSIS REPORT** 7/30/57

DASHT-I-BAKWA AREA		
Location	Bakwa Camp Well	Karez
Conductivity:		
$EC \times 10^6$ @ 25° C	1100	790
% Na	94	46
pH	7.8	7.7
Dissolved Solids:		
ppm Salt 1/	704	627
Tons/A. F. 2/	.96	.85
S.A.R:	5.0	2.8
Irrigation Classification:	C3-S1 4/	C3-S1
Cations me/1:		
Ca	1.83	1.82
Mg	2.85	2.84
Na	7.45	4.13
K	.12	.06
SUM		8.85
Anions me/1:		
CO_3		0
HCO_3		4.38
Cl		1.77
SO_4 3/		2.70
SUM		8.85
Number of Samples:	1	2

1/ Dissolved Solids (ppm) calculated from me/1 x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

Table 4 GROUND WATER ANALYSIS REPORT 7/30/57

MARJA AREA

Location	American Well	American New Well	Afghan Well
Conductivity:			
$ECx10^6$ @ 25° C	3434	1500	5566
% Na	63	65	62
pH	7.6	7.6	7.6
Dissolved Solids:			
ppm Salt 1/	2196	1075	3483
Tons/A. F. 2/	2.90	1.40	5.04
S.A.R:	9.0	6.2	12.5
Irrigation Classif:	C4-S3 4/	C3-S2	C4-S4*
Cations me/l:			
Ca	5.64	2.00	10.27
Mg	7.33	3.20	11.38
Na	21.80	10.00	36.80
K	.16	.10	.22
SUM	34.93	15.30	58.67
Anions me/l:			
CO_3	0	0	0
HCO_3	2.73	2.13	3.10
Cl	18.16	5.16	31.02
SO_4 3/	14.04	8.01	24.55
SUM	34.93	15.30	58.67
Number of Samples:	5	1	3

* Not suitable for irrigation since conductivity is greater than 5000 $ECx10^6$

1/ Dissolved Solids (ppm) calculated from me/l x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

Table 5

GROUND WATER ANALYSIS REPORT

9/30/57

NAD-I-ALI AREA

Location	East of C Village Well	West of C Village Well	North of D Village Well	D Village Well	Nad-i-Ali Fort Well	Chah-i-Anjir Well	No. of A Village Well	So. of A Village Well	East of B Village Well	West of B Village Well
Conductivity:										
$ECx10^6$ @ 25° C	7444	1540	4360	3550	1360	960	4130	3580	5980	5600
% Na	69	61	55	60	32	57	57	52	79	69
pH	7.7	7.6	7.4	7.4	7.5	7.7	7.5	8.0	8.6	7.6
Dissolved Solids:										
ppm Salt 1/	5164	989	2909	2336	3331		2669	2371	3881	4164
Tons/A. F. 2/	7.06	1.35	3.96	3.18	4.53		3.63	3.22	5.88	5.66
S.A.R:	15.0	5.4	8.0	8.0	2.0	3.6	8.0	5.6	18.0	13.0
Irrigation Classif:	C4-S4* 4/	C3-S1	C4-S2	C4-S2	C3-S1	C3-S1	C4-S2	C4-S2	C4-S4*	C4-S4*
Cations me/l:										
Ca	11.90	2.87	10.20	6.90	4.95	1.96	9.20	8.60	6.35	9.20
Mg	15.20	2.93	10.40	7.40	4.47	2.08	9.20	9.00	6.75	10.60
Na	56.80	9.16	25.60	22.00	4.68	5.37	24.90	19.50	48.00	43.60
K	.40	.06	.20	.20	.48	.05	.20	.30	.40	.20
SUM	84.30	15.02	46.40	36.50	14.68	9.46	43.50	37.40	61.50	63.60
Anions me/l:										
CO_3	0	0	0	0	0	0	0	0	.40	0
HCO_3	3.05	3.13	2.50	2.92	4.33	3.45	2.20	2.40	2.20	19.25
Cl	45.60	6.41	22.25	15.70	3.25	2.51	22.50	15.75	33.25	42.2
SO_4 3/	33.65	5.30	21.65	17.88	7.10	3.50	19.20	19.25	25.65	2.15
SUM	84.30	15.02	46.40	36.50	14.58	9.46	43.90	37.40	61.50	63.60
Number of Samples:	1	1	1	1	1	3	1	1	1	1

* Not suitable for irrigation since conductivity is greater than 5000 $ECx10^6$.

1/ Dissolved Solids (ppm) calculated from me/l x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

Table 6 GROUND WATER ANALYSIS REPORT 7/30/57

TARNAK AREA

Location	Tarnak Camp Well 263' 10 ' Water Level	New Airport Well	Kalantar Karez	Ismael Karez	Akdad Karez	Tarnak Karez	Shamshir Karez	Zareo Karez	Mukua Karez
Conductivity:									
$EC \times 10^6$ @ 25° C	1280	4113	1828	3216	1080	1120	3298	2960	3447
% Na	50	72	57	58	66			59	59
pH	8.3	8.1	7.7	8.6	8.4	8.2	7.9	7.5	7.7
Dissolved Solids:									
ppm Salt 1/	861	2950	1079	2240	818	835	2383	2077	2474
Tons/A. F. 2/	1.17	4.0	1.47	3.05	1.10	1.13	3.23	2.82	3.36
S.A.R:	3.8	14.0	5.2	7.5	5.2	5.0	7.7	7.2	8.0
Irrigation Classif:	C3-S1 4/	C4-S4	C3-S2	C4-S2	C3-S1	C3-S1	C4-S3	C4-S2	C4-S2
Cations me/l:									
Ca	2.83	4.08	1.86	3.69	1.22	1.01	4.17	4.51	4.22
Mg	3.97	9.12	4.80	10.70	3.00	3.38	10.77	8.44	10.86
Na	7.06	33.40	9.42	20.20	7.60	7.11	21.40	18.77	22.60
K	.20	.20	.13	.15	.08	.66	.40	.18	.20
SUM	14.06	46.80	16.21	34.74	11.90	12.16	36.74	31.90	37.88
Anions me/l:									
CO_3	.53	.34	.20	.56	.27	.27	.23	0	.36
HCO_3	3.07	5.43	4.67	4.72	4.34	4.15	4.24	4.60	5.74
Cl	5.40	17.45	5.48	12.30	3.44	3.20	12.65	10.90	12.62
SO_4 3/	5.06	23.58	5.86	17.16	3.85	4.54	19.62	16.40	19.16
SUM	14.06	46.80	16.21	34.74	11.90	12.16	36.74	31.90	37.88
Number of Samples:	1	4	2	1	1	2	4	1	2

1/ Dissolved Solids (ppm) calculated from me/l x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

Table 7

GROUND WATER ANALYSIS REPORT 7/30/57

OTHER AREAS

Location	Girishk Well	Kushk-i-Nakhud Well	Lashkarga Well
Conductivity:			
$EC \times 10^6$ @ 25° C	865	700	990
% Na	72	42	46
pH	7.3	8.1	7.7
Dissolved Solids:			
ppm Salt 1/	691	495	694
Tons/A. F. 2/	.94	.67	.94
S.A.R:	1.2	2.2	3.0
Irrigation Classif:	C3-S1 4/	C2-S1	C3-S1
Cations me/1:			
Ca	4.19	1.76	2.90
Mg	2.98	2.48	2.96
Na	2.06	3.25	5.02
K	.26	.10	.04
SUM	9.49	7.59	10.92
Anions me/1:			
CO_3	0	.13	0
HCO_3	6.22	3.20	2.63
Cl	1.46	4.26	3.30
SO_4 3/	1.81	0	4.99
SUM	9.49	7.59	10.92
Number of Samples:	2	1	2

1/ Dissolved Solids (ppm) calculated from me/1 x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

APPENDIX III

DEVELOPMENT COST ESTIMATES

Revised 12/6/55
Revised 8/25/56

NORTH ARGHANDAB AREA (Work Sheet For Cost Estimate)

A-1 Net irrigable gross acres = 67,635 as measured by planimeter from soil survey map, Gross Irrigable = 48,659 Acres. When development losses are deducted for Class IV lands not watered, for roads, canals, etc., the net area will be 40,235 acres.

A-2 Arghandab Dam Proration: Total Cost of Dam = \$6,607,626, allocation to flood control and power 25% = \$1,652,026 which leaves \$4,955,600 to be prorated over 194,025 acres of land. Proration to North Arghandab.. \$ 1,027,600

A-3 Cost of Nalgam Diversion and 9 intake controls for canals above Nalgam and below Arghandab Diversion Dam. Nalgam Diversion Dam estimated cost: \$665,000 prorate ½ to N. Arghandab Area: \$332,500
9 canal intake controls at \$6,000 each: 54,000
Letter Ackerman to Johnston 12/31/53 Total........................ \$ 386,500

A-4 A small construction camp will be needed to facilitate construction of the Nalgam Dam and canals to North Arghandab Area and to lower end of Central Arghandab Area. Estimate by Gavin for this camp.... \$ 200,000

A-5 Major Irrigation Distribution System - North and South Canals and distribution from Nalgam Dam estimated by Ackerman, December 31, 1953, at \$1,326,000. Charge ½ to N. Arghandab.................... \$ 663,000

A-6 Major Drainage System - Drainage must be provided for the entire area. Costs were calculated in 1953 justification Arghandab Valley Development, page 19. Cost from estimate: \$ 862,828
Interceptor drains must be added to the gross usable area 48,659 acres at a cost per acre used in the above estimate of \$16.51 per acre = 48,659 x 16.51 = 803,605
Total.. \$ 1,666,433... \$ 1,666,400

A-7 Interproject Roads - none included - there will be roads on canal and lateral banks. Kandahar to Girishk Road runs along north side of the area and will serve it.

A-8 Tile Drains (calc. at MKA costs Nad-i-Ali). It is estimated from remeasurements of the soil survey and drainage maps (8/25/56) that 18,760 acres will require tile drains on 200 meter spacing or 375 Km of drains. Average cost for tile drains was \$3,000 per kilometer. Cost = 375 x 3,000 = \$1,125,000.............................. \$ 1,125,000

A-9 Sublateral and Farm Ditches (At ACU actual costs of April, 1956). Average cost per acre sublaterals and pickup drains (ACU) = 22.38/A Total cost. Average cost per acre Farm Ditches and farm pickup drains = 9.71/A Total cost. Sublaterals and accumulator drains will be needed on 25,000 acres, or cost = 25,000 x 22.38 = \$560,000
Farm ditches and farm pickup drains on 18,500 acres @ 9.71 = 179,635
Total... \$ 739,635

A-10 Leveling (unit cost by ACU, April, 1956) equals $0.40 cm. From the drainage and soil survey maps, it is estimated that: Leveling 15,170 acres @ 150 cm per acre x 0.40/cm .... $ 910,000

A-11 This work to be contributed by the people is based on dollar eqv., costs of 6.72/A for borders and basins and 1.41/Acre for leaching irrigations. From soil surveys it is estimated 15,200 acres need such treatment or 15,200 x 8.13.................... $ 123,500

A-12 Total cost in dollars - is the sum of Columns 2 thru 11 and is the estimated total $ eqv., cost of the project................ $ 6,841,635

A-13 Cost per acre in dollars - is the estimated total cost of the project (Column 12) divided by the number of acres (Column 1) of net irrigable land: 6,841,635 ÷ 40,235 = $170.04

NOTE: Only $1,027,600 (Item A-2) is expended to date. All other items are estimated as contractors costs plus fees or ACU costs plus overhead. Serious consideration given to development of as much as possible by private capital and farmer labor could result in substantially lower total cost and in less demand for use of foreign currencies.

and furnish remarkably good grazing for a short period. Poplar, ash and willow grow along the streams. A few flowering and fruiting shrubs such as wild almond, pistachio, wild prune, cotoneaster, and silver berry appear along the dry washes, upper outwash fans and low rocky foothills. The tree tamarisk (ghaz) and cypress (cupressus torulosa or c. sempervirens) grow in isolated oases or where protected as in cemeteries or courtyards. Wild iris, tulip, poppy, penstemon, and numerous other flowering plants make beautiful meadows and the mixture of legumes and grasses make excellent pasture from February through May depending on the amount and distribution of the winter and spring rains. The saline-alkali lands and wet lands support similar vegetation to that already described for these sites but in greater amounts.

From about 1,100 meters to 2,500 meters are chiefly small valleys foot slopes and rugged foothills and mountains. The number of shrubby species and small trees increase in favorable sites but the general appearance except in early spring is still barren to scantily vegetated. Species of almond, pistachio, wild prune, hawthorn, rock rose, wild olive, barberry, privet and zizyphus appear. Grasses such as the bromes, wild ryes, aristidas, fescues and stipas become more abundant in protected places. Sycamore, poplar, ash, willow, viburnum and other trees grow in well-watered sites.

The higher and more easterly forested sites are chiefly in the Nuristan/or eastern provinces and outside the watershed of the Helmand. Here in addition to species mentioned are pine, deodar cedar, larch, oak and several associated species. The growth of trees under irrigation or along the water courses for wood and lumber is of real interest to the Afghan Government and an initial afforestation project is included in the Helmand Valley development program.

Table 9, summarizes what little information is available on the flora of the watershed. The major subdivisions of the watershed are based chiefly on elevation and climate. The subdivisions are vegetative sites based upon soil characteristics and degrees of salinity and alkalinity affecting plant adaptation and growth. The normal site for a species is indicated by a check mark and sites of limited adaptation by the letter "L". This is a tentative site grouping only. Much study is needed to furnish a good vegetative site map and classification of Afghanistan flora.

Revised 12/6/56
Revised 8/29/56

CENTRAL ARGHANDAB AREA (Work Sheet for Table I)

B-1 Gross Area - 132,220 acres, gross irrigable - 86,166 acres and net irrigable - 80,475.

B-2 Arghandab Dam prorated cost is based on allocating 25% of cost to flood control and power and the balance is prorated over 194,025 acres. Allocation to Central Arghandab = $\frac{80475}{194,025}$ x 4,955,600...... $ 2,055,300

B-3 Diversions and main canals - budget revision 8/7/56 by Shockley estimates Arghandab diversion cost as $954,270 and the cost of Arghandab So. Canal including bifurcation and waste-way works as $2,083,344. This system will serve 60,689 acres in Central Arghandab and 64,350 in Tarnak. C. Arghandab proportion of 48.54 % = $1,475,350. Tarnak Canal will serve 4,023 acres of Central Arghandab lands or 5.88% is chargeable to C. Arghandab. Shockley's budget revision 8/7/56 shows $2,639,279 as Tarnak Canal cost or .0588 x 2,639,279 = $155,190. Add ½ Nalgam Div. cost and ½ Nalgam Canal system from Ackerman's 12/31/53 estimate = $1,037,263. Total estimate.. $ 2,667,803

B-4 Work Camp estimated same as Tarnak.............................. $ 170,000

B-5 Major Irrigation System - estimated equivalent to Tarnak costs... $ 3,206,500

B-6 Major Drainage System - included in B-5 above.................. (incl.)

B-7 Interproject Roads - roads needed to connect this area to Kandahar are included in B-5 and B-6 costs above....................... (incl.)

B-8 Farm Tile Drains - soil survey shows 17,000 acres with present water tables from 1'-5' below surface, and 35,000 acres needing leaching now. Not all will be drained or leached now (14,000 acres are considered unsuitable for present development). Drains needed now are estimated as 6,000 @ 100 m spacing x 114.74 = $688,440. 10,000 @ 200 m spacing x 57.37 = $573,700. Total estimated tile drains.................................... $ 1,262,140

B-9 Sublaterals and accumulator surface drains - will be required on 56,000 acres at a cost of 22.38 per acre or (ACU's total cost as of 5/56) = 1,253,300. Farm ditches and farm pickup drains will be needed on 41,000 acres at cost of 9.71 per acre (ACU est.) 400,000. Total sublaterals and farm ditches............................ $ 1,653,300

B-10 Land Leveling - from drainage and soil maps, it is estimated:

181 acres sand spreading and deep plowing @ 154.70	=	28,005
4000 acres brush clearing and grubbing @35.71	=	142,840
4000 acres rough leveling @ 73.41	=	293,640
8000 acres moderate leveling @ 72.50	=	580,000
8000 acres disking leveling @ 7.38	=	59,040
12,181 acres land planing @ 7.92	=	96,475

Total clearing, leveling etc.,.................................... $ 1,200,000

B-11 Leaching - soil surveys show 41,300 acres needing leaching or salinity control. At \$ eqv. of borders = 6.72 and leaching irrigations = \$1.41, cost.. \$ 326,600

B-12 Total Cost of Project in dollars - is the sum of Columns 2 thru 11, inclusive.. \$12,541,643

B-13 Cost per acre - in equivalent dollars: 12,541,643 ÷ 80,475 = \$155.84

Note: Does not include estimate of costs of present development or portions which would be usable in the completed project. Private capital and farmer effort could probably do most of work items B-8 through B-11 and thereby considerably reduce the total needed for complete development.

September 11, 1955
Revised 12/6/55
Revised 12/29/56

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TARNAK AREA (Work Sheet for Table I)

C-1 The gross area contains 110,655 acres of which 74,550 is irrigable or reclaimable. Due to shortage of , 64,350 acres of the better lands will be selected for development.

C-2 Arghandab Dam prorated cost is based on allocation of 25% of cost or 1,652,000 to flood control and power and the balance 4,955,600 is prorated over 1954,025 acres. Allocation to Tarnak Area =.................................... $ 1,643,826

C-3 Cost of Diversions & Canals - in the 8/7/56 revision by D. R. Shockley, Arghandab diversion dam is estimated to cost \$1,062,297.42 and South Canal to and incl., bifurcation and wasteway works to cost \$2,074,896.77. These works will serve 125,050 acres of which 51.46% is in Tarnak area.... Tarnak portion= \$1,614,400.13. The Tarnak Canal is estimated to cost \$3,107,281.58 of which only \$182,708.15 is chargeable to C. Arghandab and \$2,924,573.43 to Tarnak. Total cost diversions and canals =........... $ 4,538,974

C-4 Buildings and Improvements - a small construction camp supplemental to Manzel Bagh. Taken from Target Estimate (11/27/55)..................... $ 170,000

C-5)
C-6) Major Irrigation and Major Drainage System - taken from Target Estimate (DRS) Rev., of 8/7/56.. $ 3,206,500
(Includes main laterals, deep drains and accumulator drains, etc.)

C-7 Interproject Roads - None - Area is served by Kandahar - Spin Baldak Road on North and on-project roads are included in C-5 & C-6. (incl.)

C-8 Farm Tile drains - data from soils and general drainability surveys indicate the following at ACU's unit costs:
20,044 acres of drains @ 100 m or less x 114.74 = 2,299,849
23,193 acres of drains @ 200 m spacing x 57.37 = 1,330,582
4,800 acres of drains over 200 m spacing x 38.34 = 184,032
Cost total tile drains.. $ 3,814,463

C-9 Sublaterals and Farm Ditches -
Sublaterals 68,000 acres x 22.38 per acre (ACU est.) = 1,528,900
Farm Ditches 68,000 acres x 9.70 per acre " " = 659,400
Total... $ 2,188,300

C-10 Land leveling - from soils surveys and based on ACU unit costs:

Brush clearing - 24 acres @ (ACU's) 35.71 =	857.00
Rough leveling - 24 acres @ 73.41 =	1,762.00
Mod. leveling - 16,720 acres @ 72.50 =	1,212,200.00
Heavy leveling - 1,602 acres @ 90.00 =	144,180.00
Disking - 13,637 acres @ 7.38 =	100,641.00
Land plowing 31,983 acres @ 7.92 =	253,305.00

Total clearing and leveling.. $ 1,712,900

C-11 Land reclamation - leaching of 13,400 acres, cost of borders and basins at 6.72 and cost of leaching @ 1.41........................ $ 108,900

C-12 Total cost Project in Dollars - is the sum of Columns 2 thru 11, inclusive.. $ 17,383,863

C-13 Cost per acre - in dollars: 16,891,242 ÷ 64,350 = $270.10

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September 10, 1955
Revised 12/6/55
Revised 8/28/56

BOGHRA (NAD-I-ALI) AREA (Work Sheet for Table I)

M-1 Net Irrigable Lands - the gross area covers 25,000 acres. Gross irrigable is estimated at 21,100 and net at 18,500.

M-2 Kajakai Dam prorate - the cost of dam less 25% allocated to flood control and power is prorated over 647,900 acres of land for which dam can supply water. Nad-i-Ali portion.................................... $ 268,600

M-3 Canals and Diversions -

1. Boghra Div. Dam & Canal (Sched. I-II of 1946 Contract (to station 31 - 800) shows cost as 6,963,515.67). Allocation by % land served = value x .169 = 1,176,834.15

2. Boghra-Marja-Shamalan (Sched. III-IV of 1946 Contract and completion in 1950 Contract = 5,362,893.73. Nad-i-Ali proportion = .3357 x .5 x value = 900,161.72

3. Lining Boghra-Marja Canals (Suppl. #11 Comp.) = 103,791.95
Nad-i-Ali prorata = .336 x value = 34,874.09

4. Boghra O. & M. (Suppl. #4) = 40,980.39

Total Nad-i-Ali prorata canals & diversions.......................... $ 2,152,850.00

M-4 Farm Machinery- for Boghra Area from Suppl. No. 2, 1950 Contract... (See # M-9)

M-5 Complete Irr. System (incl. also a major part of M-9)

Supplemental Contract #1 -	335,670.71	
1950 Contr. Nad-i-Ali Div. Dam -	116,954.60	
Supp. #11 Nad-i-Ali Completion -	435,181.87	
Supp. #11 Nad-i-Ali Comp. (1954 Contract)	114,450.01	
Total Irr. Systems..		$ 1,002,257.00

M-6 Major Drainage Systems -

Suppl. #9 (Engr.) -	3,969.25	
Suppl. #10 Nad-i-Ali W. W. & drains -	237,995.63	
8/7/56 Est. to complete by DRS (18 km drains @ $8000/km) - 80 km @ $6500	520,000.00	
Total Major Drains..		385,965.00

M-7 Interproject & on-project Roads -

Suppl. #1, Farm Access Roads -	112,004.32	
Suppl. #9, 10 Engr., & Siphon Rd. Crossings -	39,606.87	
½ Supp. #11 interproject roads & Siphon Crossings -	69,334.84	
Cost total..		$ 220,945.00

M-8 Tile Drainage - est. by ACU as 18,500 acres (100 m spacing) @ 114.74 Acre.......... $ 2,122,700

Expended to date	(Suppl. #10 (drainage) -	90,619.96
	(Suppl. #11 " -	80,909.84
	(1954 Contract " -	36,289.54
	(Suppl. #11 Compl. 6/25/56) -	245,491.38
Expended to date..........		$ 453,310.72

M-9 Pickup Drains, Sublaterals & Farm Ditches - (Major costs incl. in M-5)
A series of miscellaneous items which were a part of Boghra land development include the following:

1946 Contract Nad-i-Ali Experimental Farm -	128,271.37
Suppl. #2 (Farm Machinery) -	56,848.41
Suppl. #3 Agric. Experimental Works -	41,452.67

Incl. under M-9 as misc. items.......... $ 226,572.00

M-10 Land leveling -

Suppl. contract #1 -	25,175.69
Sched. VII 1950 out-of-contract items (land prep. and seeding) -	61,703.55
ACU's 1953-54 work (est. by Swett) -	18,296.45

Charges to land leveling.......... $ 106,176.00

M-11 Work to be contributed by the people (based on 1956 soil survey)
Reclamation cost of leaching on 7000 acres @ 8.13/acre.......... $ 56,910.00

M-12 Total cost in dollars is the sum of Columns 2 to 11 incl. and is the estimated total cost of the project.......... $ 6,542,975.00

M-13 Cost per acre - in dollars is the estimated total cost of the project (Column 12) divided by the number of acres (Column 1) in the project 6,542,975 ÷ 18,500 = $353.67

September 10, 1955
Revised 12/6/55
Revised 8/29/56

MARJA AREA (Work Sheet for Table I)

N-1 Net Irrigable Lands - the gross surveyed area included about 45,000 acres. Gross irrigable and reclaimable equals 29,869 acres. Net irrigable equals 27,600 acres.

N-2 Kajakai Dam cost - less 25% allocated to flood control and power, is prorated over 647,900 acres of land for which dam can supply water. Marja portion.. $ 400,800

N-3 Diversions & Canals - (See Boghra for details)
Marja proportion 1946 contr. Boghra Div. Dam & Sched. I-II - 1,754,805.95
Marja proportion 1946 Sched. III-IV, & 1950 Contract - 1,340,723.43
Marja proportion canal lining (Suppl. 11 compl.) - 51,895.98
Allocated costs canals & diversions.................................. $ 3,147,425

N-4 Buildings & Improvements -
Suppl. #11 1950 contract - 228,721.78
Suppl. #11 Compl. 1954 contract (6/25/56) - 553,788.17
Marja Camp Costs - 782,509.85
Allocate 2/3 Marja & 1/3 Shamalan.................................. $ 521,934

N-5 Major Irr. System (incl. A, B & C drains)
1954 Contract expended (6/25/56 Cost. Statement) - 2,115,964.00
DRS 8/7/56 est. to complete - 325,558.00
2,441,522.00
A, B & C drains est. @ 52 km x 15,000 - - 780,000.00
Marja dike (1950 Contract) - 74,915.93
Total cost major irr. system.. $ 1,736,438

N-6 Major Drainage System -
A, B & C drains est. @ - 780,000
Est. additional drainage (DRS 8/7/56) - 1,000,000
1,780,000
Less 1200 Acc. farm drains @ 100 m spacing and $3500 km - - 170,000
Est. cost major drains.. $ 1,610,000

N-7 Interproject Roads -
½ Suppl. 11 interproject roads and siphon crossings - 69,334.84
½ Interproject roads Shamalan-Marja Suppl. 11 Contract - completion 6/25/56 cost statement - 18,923.38
Total.. $ 88,259

N-8 Farm Drains -
Swett 8/25/56 ACE est. 27,600 acres @ 200 m sp. cost 57.37/A - 1,583,400
DRS 8/7/56 est. 898 km @ 3500 - 3,143,000
Estimate: Avg. of 2 above statements.................................. $ 2,363,400

H-9 Sublaterals and Farm Ditches from ACU operation schedule and 8/28/56 estimate = 618,300 + 266,200.............................. $ 884,500

H-10 Land leveling - from Soil Surveys and experience costs to date, the cost is estimated as follows by ACU:

Deep plowing 1115 acres @ 75.97 -	84,706
Sand spreading 1115 acres @ 159.00 -	177,285
Moderate leveling 8,120 acres @ 72.50 -	588,710
Heavy leveling 1115 acres @ 90.00 -	100,350
Disking 10,245 acres @ 7.38 -	75,608
Land planing 9,235 acres @ 7.92 -	73,141

Cost total land preparation.................................... $ 1,099,800

H-11 Land Reclamation by the people - ACU estimates 8/28/56 that the people will do leaching @ 8.13 per acre on 10,338 acres or cost.. $ 89,000

H-12 Total cost in dollars. - Columns 2 thru Column 11 amounts to..... $11,941,556

H-13 Cost per acre - in equivalent dollars is derived as 11,941,556 ÷ 27,600 or $432.66

SHAMALAN AREA (Work Sheet for Table I)

0-1 The Gross Area - surveyed is about 65,000 acres, gross irrigable was found to be 47,876 acres. After development losses, the net acres equal 42,325 acres.

0-2	Kajakai Dam proration - cost of dam, less 25% allocated to flood control and power, is prorated over 647,900 acres of land for which the dam can supply water. Shamalan portion..........		$ 614,600
0-3	Diversion and Canals - (See Boghra est. for details). Prorata cost 1946 Contract Schedule I & II & Div. Dam based on acreage served = .388 x 6,963,515.67 =	2,701,844.08	
	prorata cost 1946 Contract Schedule III & IV plus 1950 Contract = .50 x 6,362,893.73 =	2,681,446.86	
	1946 Contract Valley Br. Engr. =	190,754.06	
	Total allocated costs diversion and canals..........		$ 5,574,045.00
0-4	Buildings and Improvements - (See Marja Work Sheet) allocate 1/3 Marja Camp = .333 x 782,509.85..........		260,575.78
0-5 0-6	Major Irrigation Systems - (combined with 0-6) Major Drainage Systems - (combined with 0-5) Constr. cost thru 6/25/56 1954 Contr. -	966,647.44	
	Est. to complete (DRS 8/7/56)	430,081.00	
	Total..........		$ 1,396,728.44
0-7	Inter-Project and On-Project Roads - 1950 Contract Shamalan Rd. (per 3/31/55 Statement) =	309,021.42	
	½ roads in 1954 Contr. completion of Suppl. #11 (6/25/56 Cost Stat.)=	18,923.88	
	Total..........		$ 327,945.30
0-8	Farm Drains - estimated by ACU as follows: 11,388 acres(@ 200 m spacing) x $57.37 per acre plus 10,375 acres (over 200 m spacing) x 38.34 per acre..........		$ 1,051,100
0-9	Pickup drains sublaterals based on ACU est. 8/27/56 @ 22.38 per acre on 44,400 acres =	993,600	
	Farm ditches ACU est. 8/27/56 @ 9.71/acre on 16,000 acres =	157,200	
	Total ACU est..........		$ 1,150,800
0-10	Clearing & Leveling - (ACU cost estimate based on soils survey acreage):		
	Sand spreading on 800 acres @ 159.00 =	127,200.00	
	Brush clearing on 1795 acres @ 35.71 =	65,000.00	
	Rough leveling on 1795 acres @ 73.41 =	131,771.00	
	Moderate leveling on 13,495 acres @ 72.50 =	978,388.00	
	Disking on 11,700 acres @ 7.38 =	86,346.00	
	Land planing on 13,495 acres @ 7.92 =	106,880.00	
	Total clearing and leveling		$ 1,495,585

0-11 <u>Leaching and Land Reclamation by the people</u> - estimated from soils survey that 10,600 acres will need heavy leaching. Cost of borders (ACU 8/27/56) = 6.72 and irrigations 1.41 per acre.
Total cost (equivalent dollars).. $ 86,100

0-12 <u>Summary of all costs</u> in equivalent dollars.............................. $11,957,479

0-13 <u>Average per acre</u> cost = 11,957,479 ÷ $42,325 = ...$282.[illegible]

Revised 12/6/55
Revised 8/28/56

DARWESHAN AREA (Work Sheet for Table I)

P-1 Net Irrigable Acres - gross area surveyed is 73,910 acres. Acres irrigable and subject to reclamation are estimated at 55,000 acres; After development losses, the net area will be about 45,500 acres.

P-2 Kajakai Dam proration - cost of dam less 25% allocated to flood control and power is prorated over 647,900 acres of land for which the dam can supply water. Darweshan portion.................... $ 660,700

P-3 Darweshan Intake Structure - from (DRS) estimate of 8/7/56 was $615,518. The Hazar Joff supplementary canal was $99,960.......... $ 715,180

P-4 Construction Camp - is estimated (DRS 8/7/56) at.................. $ 526,830

P-5 Major Irrigation Distribution and
P-6 Major Drainage System - including main canal are est. by DRS 8/7/56 $ 5,548,455

P-7 Interproject Road - from Marja Area to Darweshan and Darweshan bridge (6/25/56 cost statement)...................................... $ 338,180

Drains - ACU estimates 8/26/56 from soil survey maps:
...es @ 100 m spacing x 114.7/... ...5,280
... @ 200 m spacing x ...

Chapter II

4. Land Use and Agriculture:

Historical Agriculture - The earliest agriculture of the watersheds of the Chakansur-Siestan Basin was undoubtedly prior to written history and is evident now only in archaelogical research which, so far, has touched only a small fraction of the vast area. The McMuron report of 1905 noted that archaelogical studies in the Siestan Basin had revealed the earliest phases of the Bronze Age. Extensive ruins cover stretches of the vast lower basins. Whereas a few straggling mud-walled villages now exist, the ruins indicate large cities of the most modern architecture of their times. This is strong evidence of a much greater agriculture than now exists. Similarly, up all the river valleys can be found today vast ruins reflecting an apparently propperous and extensive agriculture. Kala Bist is said to be mentioned in ancient history along with the earliest cities of Nineveh and Ur. French archeologists exploring near Kandahar have found ruins which they have dated back to some 2500-3000 B. C. The earliest records indicate that the Aryan race evolved north of the Hindu Khush in the Oxus Valley. Sir Kerr Fraser-Tytler in his book traces the history of the area from 500 B. C. *

The works now being undertaken in the Helmand Valley are not, as some think, for the development of "new lands" but the rehabilitation for the most part of old lands, some abandoned so long ago that native vegetation has re-established its thin but protective covering. The chances are that only a small part of the total land to be watered by the various development schemes proposed will be of virgin soil. The vast acreages of barren or scantily vegetated lands now affected to varying degrees by salts, alkali, ground water and erosion are a graphic record of past land use. They serve warning that re-expansion of agriculture into these areas must introduce radical improvements in land use practices over those employed down through the history of man's use of these lands.

* Afghanistan - Sir Kerr Fraser-Tytler, Oxford University Press, 1953.

Chapter II-A PRESENT AGRICULTURAL PRODUCTION AND ECONOMY OF S. W. AFGHANISTAN 7/29/57

In order to determine the relative contribution to the agricultural economy of the country that may be expected from the land development program now going on in the Helmand-Arghandab Valleys and Plains it is necessary to take a look at the present situation.

In a country which has no fact-gathering agencies and consequently no reliable statistics on population, agricultural land areas, crop production, marketing or other phases of economy, one must approach this subject with a great deal of caution to avoid unrealistic assumptions and conclusions. The following study is based on rationalizing the various interrelated factors so that such data as appears factual is given due weight and no deviously unreasonable data or assumptions are introduced into the final analyses.

A. Population, Living Standards and Food Consumption:

1. Population:

The available statistics on population seem to be in disagreement with other factors of cultivated acres, production levels, labor income, and dietary levels in S. W. Afghanistan. The Industrial Survey Report 1955-56 included a figure of 12,500,000 for Afghanistan and 3,000,000 for the watershed area of the Helmand sinks (Chakansur-Siestan Basins). The Tudor Report (1956) estimated 2,200,000 in the Kandahar and Girishk Provinces with about 602,000 living within that part of the watershed presently affected by the Helmand Valley development program. For the moment one can only assume these figures and proceed to study other related phases of the regional economy.

2. Wage Earnings:

Phase I of the Helmand Valley Industrial Survey reported about 3,000,000 persons in S. W. Afghanistan with an average wage income of only 3500 Afghanis per year or 290 Afghanis per month for the 500,000 assumed to be employed. In some cases lodging, food, clothing and miscellaneous items are furnished. However, it is impossible to obtain any idea as to relative worth of such incentives and some Afghans with a more thorough knowledge of conditions state that these are very minor and are not a substantial contribution to living. Housing is so easily constructed that the item of rent ordinarily does not enter into the low income living costs and so from this standpoint may be considered as an incentive.

MKA Afghan employees in certain wage brackets are given the privilege of purchasing wheat for bread from the company during periods when bazaar prices are excessive. Due to lack of market controls and storage facilities the wheat prices have fluctuated from around 4-8 Afghanis per maund at the peak of harvest to as much as 30-35 Afghanis per maund during the winter months. Having no capital to buy in large quantities and no safe place to store wheat, the ordinary worker is at the mercy of merchants who buy up the farm grain at ridiculously low prices, store it in "godowns", and then ration it out for large profits during the cold winter months. MKA by buying wheat at reasonable market levels, 10-15 Afghanis per maund, and reselling to Afghan employees at nearly the same price has in effect added at least another months wages to many employees earnings.

TABLE 10, summarizes wages and earnings of various types of workers 1/

1/ This phase of the Study was begun in 1954 and includes data from 1954 to date.

in S. W. Afghanistan. These wage levels are those reported by employees and employers during a study made by MKA for Phase I of the Helmand Valley Industrial Survey, 1955. The wage standards for MKA Afghan employees as fixed by government regulations are given for comparison.

Common laborer and apprentice earnings are about the same as the reported general average income for all S. W. Afghanistan. It is quite readily apparent that most of the common labor class, with the exception of those regularly employed by the government or MKA, must earn much less than 500 Afghanis assumed to be the average. Skilled labor earnings are commonly twice to three times the average level of a common laborer's wages.

3. Living Costs:

At the bottom of TABLE 10 is shown for comparison three levels of income based on studies of living standards. It appears that in only a few cases do even the higher wage levels of skilled workers approach the income level estimated as needed for minimum needs of a family of six persons (estimated average family group per wage earner). TABLE 11 shows how a family of six may distribute their earnings at different levels of income. Food, clothing, fuel, shelter, medication, and light would undoubtedly absorb the greatest proportion of low income earnings and about in the order listed. As earnings increase, the expenditures for these basic items are increased to more desirable levels and other expenditures are added in about the order and quantity that might normally be required. Income taxes are not imposed until gross annual earnings reach 13,000 Afghanis, however rentals or business taxes are assessed on bazaar quarters, and business earnings starting at about 200 Afghanis and increasing with size and location of the establishment and volume of business.

As can be seen by study of TABLE 11, most of the people of S. W. Afghanistan live on a wage level below 3500 Afghanis a year per family. About 8.5% earn enough to eat a sustaining diet, buy enough clothes and expend some money for housing, medication, and school. Another 3.10% earn what may be termed a reasonable standard which affords an adequate and balanced diet, sufficient clothes and utilities, contributes toward school, education and taxes and allows a small saving for investments amounting to 3.5% of the income. Even at this level, 50% of the income is required for food as compared to 29% for the average U. S. family. Less than 1% have a wage earning comparable on a food index basis to 70% of the average U. S. income. Thus only about 1/8 of the population can contribute much toward schools, hospitals, government revenue or even enjoy a very good diet highly diversified with meats, milk, fruits and vegetables (except on occasions).

4. Diets and Food Consumption:

A study of the present and potential diets reveals the effect of a strictly grain diet on land use and potential land development in S. W. Afghanistan. In TABLE 12, is shown the per capita and family consumption of various food items for four types of diets. Afghan bazaar prices (TABLES 13 and 14) and stateside grocery retail prices are used to compute comparative costs. Diet #1 is one which will furnish more than adequate calorie and protein intake, is fairly well balanced with respect to nutrient requirements, vitamins and minerals, and includes only crops grown within S. W. Afghanistan. The FAO (United Nations) International standards recommend an overall calorie intake of 2550-2650 calories and protein intake of about 65 grams daily. The U. S. Average, 1945-1955, was 3250 calories and 96 grams of protein. Diet #1 with 2800 calories and 94 grams of protein is between these values. The purchase price to the Afghan is calculated at 7.00 Afghanis per person per day. The stateside purchase price is estimated at $0.87. Neither price includes preparation, cooking and serving.

TABLE 10 COMPARISON OF WAGE SCALES IN S. W. AFGHANISTAN — 1955

TYPE OF WORKER	MONTHLY EARNINGS MINIMUM AFS	MAXIMUM AFS	OTHER INCENTIVES AFS	POSSIBLE ANNUAL INCOME AFS
Reported Afghan Scales				
Common labor	200	250	Not possible to breakdown. Some food, lodging, clothing and miscellaneous items are furnished. Total is estimated at 10% of annual wage	2600-3300
Mechanic	354	624		4700-8200
Carpenter	281	515		3700-6800
Blacksmith	354	624		4700-6800
Clerk	300	800		4000-10,500
Basket maker	281	500		3700-6600
Metal worker	370	700		4900-9200
Pottery worker	320	600		4200-8000
Rug weaver	400	800		5200-10,500
Wood worker	320	600		4200-8000
(Est. Average Cash Income	(290)	----	(No Incentives)	(3500)
MKA Wage Scales				
Apprentice	260	385	30-50	3500-5200
3rd Class	400	500	40-60	5300-6700
2nd Class	450	550	60-70	6000-7400
1st Class	500	650	65-80	6800-8700
Sub Foreman	550	750	40-60	7000-9700
Foreman	650	1250	45-100	8300-16,000
High Standard (All Costs)	2500	Over	(None)	30,500 *
Mod. Standard (All Costs)	1250	1500	(None)	17,840 *
Low Standard (All Costs)	800	1000	(None)	10,800 *

* Wage income levels for comparative study.

TABLE 13 — **COMPARISON OF EXPENDITURES FOR LIVING AND OTHER EXPENSES FOR VARIOUS INCOME LEVELS - S. W. AFGHANISTAN, 1955 CONDITIONS (FAMILY OF 6)** — 7/29/57

COST ITEM	EST. AVERAGE 1/ ANNUAL INCOME S. W. AFGHANISTAN	MINIMUM STANDARD 2/	DESIRABLE STANDARD 3/	EXCELLENT STANDARD 4/
Clothes	200	500	1700	2500
Food	3150	8000	10,0[illegible]0	13,000
Fuel	125	300	600	1000
Rent	——	400	1000	2500
Medication	——	200	400	1000
Draft Power or Transportation	——	200	300	1000
Personal & Miscellaneous	——	100	600	1000
Taxes (Business & Personal)	——	300 (Bus.)	700	2000
Religious Organ.	——	100	200	1000
School	——	100	1000	1000
Household	——	200	300	500
Laundry	——	100	200	500
Lights	——	100	400	1000
Savings	25	100	400	1000
	3500	10,800	17,840	30,500
$U.S. Eqv. @ 21,267:1	$164.57	$507.82	$838.85	$1,434.14
$U.S. Eqv. @ 42.534:1	$ 82.28	$253.90	$419.42	$ 717.05
Est. % Workers at each level	(At or below 3500) 87.55	8.41	3.11	0.93
Est. No. Workers 1/	437,750	42,050	15,550	4,650

1/ Estimated average wage earnings - Helmand Valley Industrial Survey Report, October 1955, Number of wage earners S. W. Afghanistan estimated at 500,000.
Note: Later in this report it is pointed out that the population figure is probably 1/2 that quoted here.

2/ Studies conducted by ICA and MKA and verified by numerous Afghans indicate this as about the minimum level.

3/ A standard which will allow normal living, medical care, and education.

4/ Equivalent to less than 1955 average U. S. per capita income.

TABLE 1 summarizes the present studies of work performed under these authorizations and other letters and agreements on file. A more complete list of drawings, maps, reports and special studies are listed in the appendix hereto and under each area supplement.

2. Purpose of Surveys and Reports.

Briefly stated, the soils and drainability surveys, maps and reports, are a compilation of detailed observations, measurements and analyses of the land and its associated features, made and interpreted by skilled technicians for the primary purpose of describing and evaluating the potential use and productivity of a parcel of land and the problems inherent with its development and use.

Summarized from the various contracts and work orders listed above the specific purposes of the Helmand Valley surveys are to determine:

1. The relative suitability for present or potential irrigation of each soil and soil condition mapped, (lands classed as presently irrigable, irrigable when reclaimed, not recommended for irrigation - with potential land capability classification of the first two categories);

2. The kinds and relative degrees of intensity of problems to be overcome in developing and using the land (salts, alkali, wetness, leveling, erodibility, flood hazards, soil behaviour under irrigation);

3. The best suited crops and sequences of crops for each major group of soils and soil conditions;

4. The crop and soil water requirements (soil properties affecting irrigation layout, crop use affecting delivery requirements); and,

5. The relative economics of development and use (estimated development costs, gross and net returns and cost-benefit ratios.

3. Organization and Presentation of Data and Reports.

Because of the volume of data in the form of maps, tables, logs, it has been found impractical to condense all this material into summary reports. Much of the data such as pit logs and laboratory analyses will be constantly referred to as development progresses into each area. To facilitate the use of working data as well as afford a usable brief report on each project the Helmand Valley Agricultural Surveys are arranged as follows:

1. General Report.

2. Supplemental reports by areas.

3. Appendices to supplemental reports containing legends, soil profile and deep pit logs, laboratory analyses, infiltration and leaching trials and previous preliminary or interim reports.

Table 13

30 BAZAAR PRICES FOR AGRICULTURAL PRODUCTS AT KANDAHAR

(Afghanis per Maund)

1 Maund = 10 #'s

[illegible]	DEC. 1955	JAN. 1956	FEB. 1956	MAR. 1956	APR. 1956	MAY 1956	JUN. 1956	JUL. 1956	AUG. 1956	SEP. 1956	OCT. 1956	NOV. 1956	DEC. 1956
[illegible]	14.00	17.00	13.00	15.00	16.00	14.00	14.00	15.00	16.00	18.00	16.00	15.00	14.[illegible]
[illegible]	6.00	4.00	4.00	5.00	5.00	4.00	3.00	3.00	4.00	3.00	2.50	2.00	3.[illegible]
Alfalfa Green	2.00				5.00	3.00	2.00	3.00	3.00	2.00	1.50	2.00	2.[illegible]
Alfalfa Seed	—									20.00	20.00	20.00	20.[illegible]
[illegible]	[illegible]	8.00	8.00	8.00	8.00	8.00	8.00	8.00	7.00	12.00	11.00	12.00	12.[illegible]
[illegible]	—												
[illegible]	—												
Cotton (Lint)	96.00	76.00	100.00	100.00	100.00	100.00	100.00	100.00	90.00	90.00	90.00	90.00	85.[illegible]
[illegible]	—						12.00	7.00	6.00	5.00	6.00	16.00	—
[illegible]	25.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	25.00	30.00	25.00	24.00	23.[illegible]
[illegible] Fresh	10.00						15.00	8 – 10	10.00	12.00	14.00	20.00	30.[illegible]
[illegible] Dry	[illegible]	50-110	50-110	50-110	50-110	50-110	50-110	50-110	50-120	60-80	60-90	60-75	60-[illegible]5
[illegible]	[illegible]	45.00	44.00	44.00	30.00	30.00	30.00	30.00	30.00	45.00	45.00	45.00	40.[illegible]
[illegible]		Sheep - 16-20 ea.;			Cow 55-100 ea; Camel 30-[illegible] ea					Cow-150; Sheep-40; Camel-200			
[illegible]	[illegible]	70.00	70.00	70.00	60.00	60.00	60.00	60.00	60.00	55.00	60.00	70.00	70.[illegible]
[illegible]	—					4.00	5.00	5.00					
[illegible]	—												
[illegible]	—												
[illegible]	[illegible]	19.00	19.00	19.00	19.00	19.00	19.00	19.00	17.00	22.00	20.00	16.00	16.[illegible]
[illegible]	[illegible]	9.00	10.00	10.00	10.00	6.00	6.00	8.00	6.00	10.00	8.00	10.00	10.[illegible]
[illegible]	13.00												
[illegible]	[illegible]	75.00	75.00	75.00	70.00	60.00	60.00	60.00	60.00	70.00	70.00	70.00	70.[illegible]
[illegible] Oil or Fats	[illegible]	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	140.00	160.00	160.00	170.[illegible]
[illegible]	[illegible]	10.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	16.00	16.[illegible]
[illegible] Season	3.00								6.00	2.50	2.50	3.00	4.00
[illegible]	[illegible]					15.00	10.00	10.00	8.00	4.00	10.00	10.00	10.00
[illegible]	—												
[illegible]	3.00	6.00	8.00	12.00	10.00	6.00	8.00	8.00	8.00	8.00	10.00	10.00	12.00
[illegible]	4.00												
[illegible]	2.00												
[illegible]	3.00	3.00	3.00							—	—	—	5.00
[illegible]	3.50	3.00	3.00							—	—	4.00	4.00
[illegible]	—								6.00	2.00	2.00	3.00	3.00
[illegible]	11.00				15.00	15.00	10.00	9.00	12.00	—	—	—	—
[illegible]	3.00									15.00	20.00	18.00	—
[illegible]	—					10.00	10.00	10.00	6.60				
[illegible]	86.00									90.00	130.00	120.00	120.00
[illegible]	—												

BAZAAR PRICES FOR AGRICULTURAL PRODUCTS AT KANDAHAR
(Afghanis per Maund)
1 Maund = 10 #'s

Items	DEC. 1955	JAN. 1956	FEB. 1956	MAR. 1956	APR. 1956	MAY 1956	JUN. 1956	JUL. 1956	AUG. 1956	SEP. 1956	OCT. 1956	NOV. 1956	[illegible] 1956	JAN. 1957
[illegible] Beans/Peas	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	10.00	11.00	9.00	9.[illegible]0	
[illegible] Flour	16.00	18.00	18.00	16.00	17.00	15.00	16.00	17.50	17.50	22.00	20.00	16.00	17.00	
[illegible]	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	100.00	80.00	45.00	45.00	
[illegible]	3.00	3.00	3.00	3.00						(45 af. camel load [illegible]				
[illegible]	2.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50		30 af. in winter)			
[illegible]	———													
[illegible] (grain)	10.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	10.00	10.00	10.00	12.00	
[illegible]	5.00	5.00	5.00							6.00	5.00	8.00	12.00	
[illegible]	10.00							10.00	15.00					
[illegible]	20.00					12.00	10.00			—	—	—	—	
[illegible]	20.00					6.00	6.00			—	—	—	—	
[illegible]	20.00	40.00	60.00					10.00	10.00	10.00	12.00	20.00	32.00	
[illegible]	10.00	40.00	40.00	40.00						50.00	60.00	40.00	50.00	
[illegible]	———						20.00	20.00	20.00	12.00	—	—	—	
[illegible]	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	70.00	65.00	85.00	10[illegible].00	
Tobacco	[illegible]	[illegible].00	20.00	25.00	30.00	40.00	50.00	30.00	40.00	30.00	30.00	30.00	3[illegible].00	
[illegible]	60.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00					
[illegible]	20.00	20.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	each	25.00	18.00	20.00	each
[illegible] (Cottage Cheese)	15-25	15-25	15-25	15-25	15-25	15-25	15-25	15-25	15-25	---	6-8	6-8	6-10	
[illegible]	.60	.60	.60	.60	.60	.60	.60	.60	.60	each	0.60	0.70	0.[illegible]5	
[illegible]	130.00	160.00	160.00	160.00	160.00	160.00	120.00	160.00	120.00	90.00	90.00	50.00	10[illegible].00	
[illegible]	50.00									30.00	30.00	35.00	[illegible].00	
[illegible]	75.00	75.00	75.00	75.00	75.00	75.00	90.00	90.00	90.00	80.00	60.00	60.00	80.00	
[illegible]	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	60.00	60.00	

Animal Hire Rates:

Donkey load – 1 af from 200 yds – 1/2 mi. 1.25 to 1 mi. 1.50 to 3 mi.

Camel haul – mushk-i-Nokhud to Kandahar = 1 Afg/mile

Table 13 (Cont'd.)

BAZAAR PRICES FOR AGRICULTURAL PRODUCTS AT KANDAHAR
(Afghanis per Maund)
1 Maund = 10 #'s

	1957							20 MONTHS		
CROPS	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	HIGH	LOW	AVERAGE
Wheat	13.00	15.00	15.00	15.00	16.00	16.00	17.00	18.00	13.00	15.2
Straw	3.50	3.50	3.50	3.00	3.00	3.00	3.00	5.00	2.50	3.45
Alfalfa (Hay)(Dry)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Alfalfa Seed	36.00	37.00	37.00	38.00	38.00	39.00	36.00	39.00	20.00	31.00
Corn (Grain)	9.00	9.00	9.00	9.00	10.00	10.00	10.00	12.00	9.00	9.2
Cotton (Lint)	80.00	80.00	80.00	80.00	80.00	80.00	100.00	100.00	76.00	89.8
Melons	—	—	—	—	—	—	8.00	16.00	5.00	8.5
Rice	25.00	25.00	26.00	35.00	35.00	30.00	30.00	35.00	23.00	26.2
Grapes (Fresh)	—	—	—	—	—	10.00	10.00	30.00	10.00	14.1
Grapes (Dry)	50.00	80.00	85.00	90.00	85.00	80.00	—	120.00	40.00	77.5
Meat (Beef)	45.00	45.00	45.00	50.00	45.00	45.00	40.00	50.00	30.00	40.8
Hides: Sheep	30.00	35.00	40.00	40.00	40.00	40.00	40.00	40.00	10.00	36.1
Cow	150.00	160.00	150.00	140.00	150.00	150.00	150.00	150.00	50.00	144.4
Camel	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	80.00	191.1
Wool	50.00	65.00	60.00	60.00	60.00	60.00	160.00*	160.00	40.00	60.9
Blackeye Peas	20.00	17.00	20.00	20.00	20.00	15.00	18.00	22.00	15.00	18.6
Potatoes	10.00	10.00	12.00	18.00	20.00	20.00	10.00	20.00	6.00	10.5
Winter Peas	9.00	9.00	9.00	9.00	9.00	9.00	9.00	18.00	9.00	10.1
Mutton	80.00	85.00	90.00	90.00	80.00	80.00	70.00	90.00	60.00	73.0
Sheep Oil or Fats	155.00	155.00	140.00	160.00	155.00	130.00	140.00	170.00	90.00	123.7
Milk	14.00	16.00	14.00	14.00	14.00	14.00	16.00	16.00	10.00	12.9
Tomatoes	—	—	—	—	—	—	6.00	15.00	4.00	9.5
Onions	14.00	16.00	24.00	24.00	8.00	16.00	4.00	16.00	4.00	10.7
Table Beets	20.00	20.00	18.00	18.00	18.00	—	—	20.00	4.00	16.3
Radishes	.75	.75	.50	—	—	—	—	5.00	2.00	3.5
Carrots	4.00	3.00	4.00	—	—	—	—	4.00	3.00	3.5
Turnips	4.00	4.00	4.00	—	—	—	—	4.00	2.00	3.1
Squash	3.00	4.00	4.00	5.00	—	—	—	6.00	3.00	4.4
Cucumbers	—	—	—	—	1.50ea	.50ea	.50ea	15.00	9.00	12.5
Cabbage	60.00	60.00	40.00	—	—	—	—	60.00	15.00	35.5
Egg Plant	—	—	—	—	—	1.00ea	.25ea	6.60	10.00	9.1
Cauliflower	—	—	—	—	—	—	—	130.00	80.00	108.0

* Washed & cleaned

Table 13 (Cont'd.)

BAZAAR PRICES FOR AGRICULTURAL PRODUCTS AT KANDAHAR
(Afghanis per Maund)
1 Maund = 10 #'s

7/25/57

	1957							20 MONTHS		
CROPS	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	HIGH	LOW	AVERAGE
Dry Beans/Peas	—	—	—	—	—	—	—	11.00	9.00	9.5
Wheat Flour	15.00	17.00	16.00	17.00	12.00	17.50	18.50	22.00	15.00	16.9
Sugar	45.00	55.00	70.00	70.00	60.00	90.00	45.00	100.00	45.00	55.5
Spinach	6.00	6.00	5.00	8.00	—	—	—	6.00	3.00	4.0
Wood (Split Mulberry)	4.00	2.50	3.00	3.00	3.00	3.00	3.00	4.00	2.50	2.7
Barley (Grain)	10.00	9.00	10.00	9.00	9.50	9.50	10.00	12.00	9.00	9.5
Pomegranates	14.00	20.00	30.00	—	—	—	—	30.00	5.00	11.0
Peaches	—	—	—	—	—	—	6.00	10.00	6.00	9.0
Apricots	—	—	—	—	14.00	10.00	4.00	20.00	4.00	11.6
Plums	—	—	—	20.00	12.00	10.00	—	20.00	6.00	17.3
Apples	32.00	32.00	—	—	—	—	8.00	60.00	10.00	23.8
Figs (Dry)	40.00	60.00	60.00	60.00	—	—	—	60.00	40.00	48.4
Figs in Season	—	—	—	—	—	—	40.00	40.00	12.00	22.4
Nuts	100.00	100.00	100.00	120.00	—	—	—	120.00	65.00	83.2
Tobacco	40.00	40.00	60.00	60.00	50.00	50.00	60.00	60.00	14.00	36.8
Dates	—	100.00	100.00	—	—	—	—	100.00	40.00	52.7
Chicken EACH - -	25.00	25.00	25.00	25.00	25.00	25.00	15.00	25.00	15.00	23.3 EACH
Mast (Cottage Cheese)	8.00	10.50	16.00	16.00	16.00	16.00	16.00	25.00	6.00	18.3
Eggs EACH	.75	.75	.75	.75	.75	.75	.75	.75	.60	.62 EACH
Butter (Milk)	160.00	160.00	160.00	160.00	160.00	160.00	160.00	160.00	90.00	135.00
Poppy Seeds	43.00	43.00	50.00	55.00	50.00	50.00	—	50.00	43.00	44.1
Almonds	80.00	75.00	80.00	75.00	75.00	75.00	—	90.00	60.00	77.3
Goat Meat	60.00	60.00	60.00	60.00	60.00	60.00	50.00	60.00	50.00	54.0
Animal Hire:										
Camel	6.00	6.00	5.50	6.00	5.50	5.00	5.00	6.00	5.00	5.5
Donkey (Per Mile)	5.00	5.00	5.50	5.50	5.50	5.00	5.00	5.50	5.00	5.2
Horse	6.50	6.50	7.00	7.00	7.00	7.50	7.50	7.50	6.50	7.0
Oxen Team (Per Day)	30.00*	30.00*	35.00*	32.00*	80.00	75.00	75.00	80.00	60.00	69.1

* Jan.-April for 1 oxen only - other months for 1 ox team (2) plus driver.

December 20, 1955

TABLE 14

Multiply Values x 52 **to obtain annual consumption values.**

Average Quantity of Food Products Consumed at Home Per Household Per Week by Nonfarm Families, by Annual Net Money Income Class, United States, Spring 1942

FOOD PRODUCTS	Under $1,000	$1,000-$1,999	$2,000-$2,999	$3,000 or Over
Major Food groups:	POUNDS	POUNDS	POUNDS	POUNDS
Milk (total equivalent, excluding butter)..	18.6	27.2	29.3	33.6
Eggs....................................	1.5	2.2	2.4	2.5
Meat, poultry, and fish..................	4.1	7.0	9.7	12.1
Fats and oils (including butter and fat cuts)	3.2	3.8	3.8	4.2
Grain products...........................	11.3	10.8	10.7	11.1
Dry beans, peas, and nuts................	1.2	1.2	1.0	.8
Potatoes and sweetpotatoes...............	7.1	9.3	9.3	9.9
Citrus fruit and tomatoes................	4.8	7.9	11.6	15.0
Green and yellow vegetables..............	4.9	6.6	8.1	9.4
Other vegetables and fruit...............	6.5	9.6	11.7	13.7
Sugar and sweets.........................	2.6	3.1	3.3	3.4
Selected products:				
Whole milk...............................	10.7	17.3	20.7	23.0
Butter...................................	0.7	1.1	1.3	1.7
Beef.....................................	1.3	2.4	3.4	4.2
Pork and lard............................	2.8	3.0	3.2	3.5

POTENTIAL U. S. HUMAN CONSUMPTION PER CAPITA

CROP	POUNDS	CROP	POUNDS
Corn	68.1	Citrus, fresh equivalent	112.2
Soybeans for beans	3.2	Other (deciduous trees, vines, berries)	215.0
Peanuts, picked and threshed	6.0		
Sugarcane, raw Sugarbeets, raw	108.0	Vegetable fat	14.9
		Animal fat	38.0
Potatoes, white	125.0	Beef and veal, (all cattle and calves)	81.8
Beans, dry edible, clean	6.5		
Truck crops, fresh, farm weight	119.7	Milk Products (dairy cows)	1,013.5
Truck crops, processed, farm wt.	51.4	Lamb and mutton (sheep and lambs)	5.8
Cotton	33.7	Pork (excluding lard) (sows)	85.7
Tobacco	10.9	Wool, grease basis	6.0
Oats and barley	8.9	Eggs (hens and pullets)	43.0
Wheat	218.7	Chickens (Including broilers)	27.3
Rice, rough	5.8	Turkeys	4.8

From a study of TABLE 11 it can be seen that this diet can only be utilized by those in the upper income bracket or about 1% of the population.

Diet #2 was described by an Afghan in the next income bracket, 17,840 Afghanis per year. It can be seen at once however that the extremely high calorie and protein intake is unnecessary. The cost also is much beyond the capacity of this income. It is quite probable that this person, having previously been on an almost wholly grain diet was reluctant to give up the extra "non" (bread) when he reached an income level which would allow the substitution of other foods. By reducing the amount of wheat consumed to 1 pound per person per day the calories and protein intake would be cut to about the proper figure and more money allowed for other foods and for clothes and other necessities.

Diet #3 is that most common among Afghan laborers doing hard manual labor. Great slabs of "non" or whole grain bread are consumed each day. A little stew containing a small amount of meat and vegetables is eaten in the evening. Tea, with or without sugar, is the common drink when it can be purchased. Fresh fruits, vegetables and milk are not a regular part of the diet but are eaten when obtainable with little or no cash outlay. It can be seen that there is a large calorie and protein intake but that deficiencies may occur in vitamin and mineral balance and types of food elements. The cost of such a diet is within reach of an ordinary laborer earning 250-350 Afghanis per month when supporting no more than one other person. However, even the highest paid skilled workers must depend on this diet or a lesser one when the number per family increases to five or more. Since the average earnings are estimated at only 3500 Afghanis per year and the steady wage earners represent probably 1/6 of the total population, the average diet which can be afforded at 90% of gross earnings is .306 of that shown or represents 1650 calories and 56 grams of protein per person per day. Food statistics prepared by the United Nations show the following calorie and protein intake levels:

India	1620 Cal.	&	43	gms.	protein
Indonesia	1520 "	"	35	"	"
Phillipines	2050 "	"	42	"	"
Japan	2100 "	"	54	"	"
U. S. A.	3250 "	"	108	"	"

Diet #4 is that of the average U. S. non-farm population and requires 29% of U. S. average earnings. This may be compared to 90% of the average Afghan income expended for a diet containing only one-half the calorie level. TABLE 14 is included to show the proportionate use of various food and farm products in the U. S.

5. Living Standards:

TABLE 15, summarizes the comparative costs of the diets shown in TABLE 12 and Wage Levels shown in TABLES 10 and 11 so as to reflect relative costs of living, using food requirements as the basis for comparison. Briefly the situation may be stated in this way. The average U. S. citizen, living on a standard higher than most places in the world, received $1,400.00 in 1955 of which he spent 29%, or $405.88 for a 3250-calorie diet containing 96 grams of protein, 160 pounds of meat, and well balanced with respect to fruits, vegetables, minerals, and vitamins. The average person in S. W. Afghanistan received $17.50 (at 40:1) of which he spent 90%, for a 1600-calorie diet containing 55 grams of protein, 15 pounds of meat, and very little fruits and vegetables. Over 90% of the energy and protein was from small grains. Minerals and vitamins and other food elements were not well-balanced.

Table 15 COST OF LIVING INDEX BASED ON WAGE EARNINGS AND RELATIVE FOOD COSTS 7/29/57

Per Capita Annual Cost of Food 1/				% Wage Earnings Spent on Food 2/		9	3/ Food Cost Ratio: Afghan / U. S. A.	4/ Cost of Living Index: Afghan / U. S. A.	Type Of Diet (TABLE)
Afghanistan Prices			Stateside Cost of Same Food	Single Afghan Worker	Per Capita Afghan	Per Capita U. S. A.			
Afghanis	Dollars 21.27:1	Dollars 40:1							
Afs.	$	$		%	%	%			
2556	120.09	63.51	319.38	73.02	365.0	22.81	0.287	16:1	#1
2594	121.91	65.33	339.45	74.11	371.0	24.25	0.276	15:1	#2
1989	93.44	48.91	100.38	56.83	284.0	7.17	0.709	40:1	#3
3667	171.92	91.25	$\boxed{405.88}$	104.77	524.0	$\boxed{29.00}$	0.234	18:1	#4
$\boxed{1630}$	29.60	15.50	31.79	18.00	$\boxed{90.0}$	2.27	0.709	40:1	#5

1/ Based on 1953-55 bazaar prices in Afghanistan and retail grocery prices in the United States.

2/ A single Afghan worker supporting no family can afford a balanced diet at about 75% of his wage earnings. The per capita income will allow at 90% of the income, a low (1600) calorie, moderate protein (56 grams), diet consisting almost wholly of grain products. The Afghan costs for this diet and stateside costs for average U. S. diet are shown in heavy outline above.

3/ Based on cost of food at each location adjusting exchange ratio to 31 Afghanis 1 Dollar.

4/ Ratio of percent of per capita income required to purchase equivalent quantities of food.

Since this is an average figure many must live on less. The relative costs in relation to income are 40:1 for the type of diet which the Afghan per capita wage earnings can buy. Only single Afghan workers supporting no families can afford a balanced diet such as #1 in TABLE 12 . The number of such single workers is not known. From TABLE 21 it is estimated 8.4%, may earn enough to support families with an 1800-calorie, 60-gram protein diet that is fairly well balanced or a higher calorie intake with less meats, fruits, and vegetables. Another 3.1% can afford for their families a well balanced 2200-calorie, 73-gram protein, diet which is well in line with the international standard recommendations of 2500-2600 calories and 65 grams of protein as average. Less than 1% can live extremely well and feed their families a wide choice of well balanced foods.

B. A Correlation of Population, Food Consumption, Crop Acreage and Crop Yields:

In TABLE 16 , an attempt has been made to project present and potential food consumption in terms of the annual demand for various agricultural products. At present grain products are about 66% by weight of all food products consumed and 82% of all solid foods (vegetables excepted). A change of living standards to allow a normal calorie and protein intake and balanced diet for 90% of the people would increase the consumption of grain products by only 4.21% but would increase the total food consumption by 283%.

In the study of diets among farmers, laborers and townspeople of the Kandahar area it was found, as shown above, that nearly 80% of the population consume a diet almost wholly of grains with small quantities of fruits, vegetables and meats at an average level of 1650 calories and 56 grams of protein daily. While single workers not supporting a family are known to consume up to 3 pounds of whole grain breads (non) daily the average of all workers and non-workers is nearer one pound. This is based on observations and measurements of diets and comparison of the national labor income estimated at an average of 3500 Afghanis per annum with food prices (1954-55).

Present wheat production has been variously estimated at 7.5 bushels (Tudor Committee) 8.3 bu. (average of Stage 1, 1953 Helmand Valley Report and 10 (1955 Report on production increases in the Helmand Valley).

Acreages in all crops was estimated for the gross irrigable acres of 1,158,500 acres shown on Map LD-17-R4 as 420,000 acres in 1956. Very little grain products appear to be exported or imported. There is movement between towns within a province and some between provinces in years of low yield. In general, however, grains produced within the watershed are consumed there.

If we assume that the population of S. W. Afghanistan is 3,000,000 and average whole grain consumption is near 1# per day, 602,540 tons must be consumed annually. Allowing for seed and for 10% wastage this would require, at the estimated level of 7.5 bushels per acre (Tudor report), roughly 2,950,000 acres. This is 2½ times the total acreage estimated potentially irrigable and 7 times that estimated annually cultivated in the development area. To produce the above amount on the 420,000 acres estimated presently farmed in the Helmand-Arghandab area would require a production of 52.5 bushels/acre. Since the per capita food consumption figure is well in line with that prevailing in Asia it is evident that the population figure is too high. All studies indicate less than 500,000 acres producing wheat in all of the Helmand-Arghandab areas surveyed or authorized for survey. The upper Tarnak, upper Arghastan and all small upper valleys of the entire Chakansur basin watershed could hardly account for more than another 175,000 acres farmed to wheat each year. The only conclusion that can be drawn is that the population figure of 3,000,000 is too high. A figure somewhere near 1,500,000 would be more reasonable.

7/29/57

Table 16 ESTIMATED PRESENT AND POTENTIAL CONSUMPTION OF FOOD PRODUCTS IN SOUTHWEST AFGHANISTAN

Food Item	Diet #1	Diet #2	Diet #3	Diet #4	Diet #5	Annual 1/ Present Consumption Tons	Annual 2/ Potential Consumption Tons	
1/ Use ratio present	0.0311	0.0841	0.0875	0.0093	0.7880	1,500,000 Population	1.5 M Population	3.0 M Population
Wheat	0.750	0.750	2.00	0.450	0.615	205,360	231,320	462,640
Rice	0.15	——	——	0.040	——	1,370	21,630	43,260
Corn	0.10	0.25	1.00	0.002	0.306	96,610	61,650	123,300
Fruits	1.00	0.70	——	0.667	——	26,335	212,620	425,240
Meat	0.20	0.12	0.120	0.446	0.037	16,450	49,440	98,880
Milk	0.90	0.18	——	1.35	——	10,000	175,000	350,000
Fats & Oils	0.10	0.05	0.005	0.175	0.002	3,570	22,720	45,440
Vegetables	2.00	1.00	0.50	0.778	0.153	87,000	391,000	782,000
Sugar	(neg.)	0.016	——	0.152	——	770	15,800	31,600 *
Eggs	0.05	0.05	——	0.110	——	8,550	38,440	76,880 *
Dried Peas & Beans	(neg.)	——	——	0.030	——	80	11,300	22,600 *
Nuts	(neg.)	——	——	0.016	——	45	2,000	4,000 *
Potatoes	(neg.)	——	——	0.428	——	1,100	58,600	117,200 *
2/ Use ratio Potential	0.50	0.30	0.10	0.10	——	453,910	1,291,500	2,583,000
# Per Day	5.25	3.116	3.625	4.644	1.113	455,192		

* Potential consumption in diets #'s 1 and 2 may increase to 1/2 of that in diet #4 as standards of living increase.

It is possible by a series of rationalizations to arrive at some reasonable agreement among the various factors of population, food consumption, food production, crop and livestock yields and crop acreages. The steps and conclusions reached are as follows:

1. Surveys and measurements of survey maps and aerial photos give a fairly reliable picture of orchards, vineyards and other crop lands for the Arghandab, Helmand Valley and Chakansur areas below the two reservoirs. This figure was used as a basis for projection to other less known areas. Acreages agreed fairly well except for the relation of grains to food estimated consumed.

2. Data on shipments of fresh and dried fruits, local fruit consumption and spoilage was used to check estimates of fruit production based on acreages and previously assumed yields. The acreages and yields were adjusted to agree fairly well with the above data.

3. Reducing the population figure to 1,500,000 another series of comparisons were made as illustrated in Table 17 . The first column used the food consumption data from Table 16 of the report and the 1955 estimate of cropped lands determining the yields necessary to supply the foodstuffs consumed. It can be readily seen that grain yields are entirely too high and tree and vine fruit yields too low. Spoilage and exports were not included, however.

4. The second column utilized the same consumption data but substituted the 1953 mean average of crop yields for all land classes at "Stage 1" level of production and determined the acreage necessary to feed 1.5 M people. The % of each land class presently cultivated was based on data used by the Tudor Committee, TABLE 18 . It can be seen that the acreage required is greater than the total potentially irrigable (from Map LD-17-R4) and nearly three times the annually cultivated acreage estimated for 1956. It is quite evident additional adjustments are needed to reconcile the various data.

5. In the last column the yields of all crops have been adjusted to those most commonly observed. The low yields assumed for grains in past estimates has resulted largely from over emphasis on the Nad-i-Ali and Seraj areas. Yields of wheat about Kandahar have been as high as 40 to 50 bushels in many fields. Tarnak, Shamalan, Darweshan yields are easily on the order of 15-25 bushels. If we take all soils and places throughout the watershed from Chakansur to elevations above 10,000 feet, somewhere near the upper limit for wheat, it is not unreasonable to assume a 15 bushel average. Orchard and vineyard yields are adjusted to the types of fruit grown and shipped, and to data on exports, local consumption and spoilage. The high acreage of pomegranates makes the average of deciduous fruit yields somewhat high. Yields of other crops appear to be in line with observations over wide areas. Acreages of orchards, and vineyards have been expanded on a reduced percentage basis from Helmand-Arghandab data. The percentage of legumes has been held about the same. The acreages of other crops have simply been computed as those needed to produce foodstuffs estimated consumed.

These several adjustments in data are all subject to modification as new facts come to light. Lacking enough basic facts one can only rationalize from those at hand. The only significant change in the total agricultural picture, if one finally accepts the population figure of 1,500,000, is that the total cropped land is less than 800,000 acres and total arable lands somewhere near 1,500,000 acres. Very few small watersheds and upper valleys have been examined but one when traveling through can observe numerous patches of grain and other crops scattered throughout these upper areas.

3 Table 1 7/30/57

SUMMARY STATUS OF HELMAND VALLEY AGRICULTURAL SURVEYS AND OUT-OF-CONTRACT AGRICULTURAL SURVEYS

AREA	AUTHORITY	FIELD WORK BEGAN	FIELD WORK COMPLETED	GROSS ACRES SURVEYED	FINAL MAPS DRAFTED	TYPE OF SURVEY
Arghandab, N.	Sup.Contr.#10, 11	March, 1953	Aug. 1953	67,635	11/8/53, 6 Sheets	Det.Recon.Soils, Drain.
Arghandab, S.	1954 Prime Contract	June, 1955	Soils 11/55 Drain. 1/56	132,220	1/17/56, 10 "	Det. Soils, Det. Recon. of Drainage
Bakwa	W.O. #38	12/55 2/5/57	(July '57)	275,000	Not Begun	Det. Recon. - Soils & Drainage
Chakansur	W.O. #29	Nov. 1954	May, 1955	554,335	1/54 - 4/55, 34 Sheets	Det. Recon. - Soils & Drainage
Darweshan	Sup.Contr.#10, 11	Aug. 1954	Oct. 1954	73,910	9/27/55, 9 Sheets	Det. Soils, Det. Recon. Drainage
Darweshan	1954 Prime Contract	June, 1956	Dec. 1956	12,500	1/13/57, 7 "	Soils & Det. Drainage Selected Areas
Farah	W.O.# 38	Not Begun	——	——	——	
Garmsel	W.O.# 39	Apr. 1955	May, 1955	123,800	8/57 11 Sheets	Recon. of Soils
Kajakai, W.	Letter of Request	Nov. 1955	Nov. 1955	12,800	12/17/55, 1 Sheet	Det. Recon. Soils & Dr.
Khash	W.O.# 38	Not Begun	——	——	——	——
Marja	Sup.Contr.#10, 11	10/5/52	2/53	45,000	5/23/53, 3 Sheets	Det. Recon. Soils & Dr.
Marja	W.O.# 5, Letters ACUP-3-40, 50, 54	10/24/56	5/15/57	35,000	11/1/56-8/57, 55 Sheets	V. Det. Soils Survey incl. drainability
Musa Kala	W.O.# 38 by Letter	Not Begun	——	——	——	——
Nad-i-Ali	1954 Prime Contract By let. 1308/1091	3/13/56	5/15/56	25,000	6/20/56, 8 Sheets	Det. Soils, Salts, Drainage
Seraj	Sup.Contr.#10, 11	June, 1954	Soils 8/54 Drainage 12/54	106,000	Feb. 1955, 9 Sheets	Det. Soils of Valley Recon. Desert portion
Seraj	1954 Prime Contract	5/18/56	8/23/56	60,000	Feb. 1957, 9 "	Det. Soils & Drainage (Desert)
Shamalan	Sup.Contr.#10, 11	Oct. 1953 Aug. 1954	Soils 9/54 Drainage 12/54	65,000	Apr. 1954, 7 "	Det. Soils, Drainage
Tarnak	Sup.Contr. #10	11/53 or 1/54	Soils 5/55 Drainage 8/54	110,655	Nov. 1955, 10 "	Det. Soils & Det. Recon. Drainage
Tarnak	1954 Prime Contract	Jan. 1956 Oct. 1956	Feb. 1956 Dec. 1956	25,000	1/56 (revisions)	Det. Soils & Drainage
ALL AREAS	————	10/52-7/57	————	1,730,155*	————	————

* Actual Acres = 1,591,655

Table 17

7/27/57

A COMPARISON OF METHODS OF ESTIMATING CROP ACREAGES AND CROP YIELDS S. W. AFGHANISTAN *

	Trial #1		Trial #2		Trial #3	
Crop Or Product	1/ Acreages from 1955 Estimate of Cropped Land	2/ Yields Based On Consumption	Acreages to Meet Consumption at Yield Levels	3/ Yields Average of Stage 1, Classes I – IV	4/ Adjusted Acreages Based On Surveys & Production Data	5/ Adjusted Yields Based On Known Acreages & Calc. Consumption
Wheat	288,900	24 Bu.	821,770	8.33 Bu.	671,040	15 Bu. 6/
Corn & Other Grains	25,120	137 "	268,690	16.0 "	(Calculated as Wheat)	
Orchards	17,550	0.5 T	11,690	.75 T	17,500	3.0 T 5/
Vineyards	59,805	0.3 T	10,350	1.7 T	50,000	2.0 T
Legume-Hay & Pasture	19,120	2.75 T	20,000	2.7 T	20,000	2.7 T
Dry Beans & Peas	380	4.2 Cwt.	265	6 Cwt.	380	4.2 Cwt.
Melons and Vegetables	11,470	7.6 T	60,000	1.45 T	29,000	3.0 T
Potatoes	575	38 Cwt.	1,100	20 Cwt.	365	60 Cwt.
Rice	3,060	8.9 Cwt.	1,025	25 Cwt.	2,200	12.5 Cwt.
Nuts	500	180 #	225	400 #	300	300 #
Miscl. Crops	17,520	—	10,000	—	4,215	—
TOTALS	444,000		1,205,115		795,000	

* From Table 16 the annual consumption of various food products by 1,500,000 people at a given diet level furnishes control data for calculations of acreages and yields.

1/ Report of July 7, 1956 to H. W. Morrison on acreage annually farmed in Helmand Arghandab watersheds + estimated acres in other areas from Drawing LD-17 R4.

2/ Yields = Calc. Consumption from Table 16 divided by acres.

3/ Yields are a weighted mean of Stage 1 for all 4 classes of land. The % of each now cropped in measured projects is as follows: Class I – 24.49%, Class II – 31.60%, Class III – 29.92% and Class IV – 13.98%. Note that the acreage is then determined by dividing gross consumption by yields.

4/ The adjusted acreages for all but grain crops are based on expanding the data from surveyed projects proportionally to the total irrigated acreage shown on Drawing LD-17 R4 but making orchard and vineyard percentages equal to Helmand Valley. The acreage of grains is based on an assumed grain yield equivalent to 15 bushels per acre of wheat.

5/ The yields of orchards and vineyards include adjustments for exports and 20-30% losses in handling. Pomegranate acreages and yields boost the tonnage for orchards. Other crop yields are approximated from known data.

6/ The Tudor Committee estimated 602,000 people within the Helmand Valley development Area. Assuming this area includes all authorized and potential projects from the two dams to the Chakansur the total irrigated land measured from surveys is about 315,000 acres and grain acreage is about 235,000. The calculated yield necessary is 17.2 bushels per acre for a 1650 calorie diet. Tudor estimated an average of 7.5 bushels per acre which would provide only a 720 calorie diet. This is obviously too low and, since the acreage figure is fairly reliable, the yields must be somewhere near that assumed for the entire watershed.

Table 12

7/28/57

ADJUSTED PERCENTAGE AND ACRES IN CROPS FOR AREAS NOW IRRIGATED AND REACHABLE BY HELMAND-ARGHANDAB WATER

CROP	% TOTAL	Acres and % by Classes			
		I	II	III	IV
		24.49	31.60	29.92	13.98
Orchards	4.58	17,000	500	—	—
Vineyards	13.08	25,000	20,000	5,000	—
Wheat	63.07	33,333	78,468	87,585	41,817
Alfalfa Hay	5.00	3,500	4,850	4,535	5,580
Vegetables	6.5	6,000	7,950	7,440	3,475
Beans	0.10	80	105	143	—
Corn	5.0	6,700	6,000	5,900	600
Rice	0.80	—	500	1,500	1,060
Potatoes	0.15	225	200	150	—
Nuts	0.10	150	120	110	—
Cotton	.75	735	950	900	415
Other Crops	1.00	935	1,210	1,140	539
TOTALS	100	96,658	120,853	114,403	53,476

Total Cultivated = 382,390 Acres

Most of the data so far presented on acreages has been based on surveys of the Helmand and Arghandab projects below and within command of the two dams and the general Helmand Valley Development program. These lie generally below the foot-hills and mountain ranges. Not all of this area has been studied. It is reasonable to assume that the innumerable small tracts of arable lands lying in the upper reaches may bring the watershed totals to somewhere near the figures reached by the rational methods discussed above. If not, the population figure will need further reduction.

C. Livestock Production and Livestock Products:

Livestock and livestock products constitute a major source of income and are not restricted to irrigated lands. Some rationalization is necessary, however, to produce reasonable agreement among the various data available on livestock production. A 1953 report of the Ministry of Agriculture shows the livestock data quoted in the following table. Prices of various livestock products and rates of animal hire are from Kandahar Bazaar and farm market prices which have been sampled monthly over a two year period.

The total area draining into the Helmand sinks (Chakansur-Siestan Area) is estimated at 125,000 square miles or roughly one-half of the country. Of this area previous estimates indicated about 42,000 square miles as range lands, 4,000 square miles of stream valleys and 15,000 square miles of sand desert (Registan). The rest was considered relatively too barren, rugged or high for productive use.

If we assume that roughly 1/3 to 1/4 of the livestock are in this one-half of the country, the following rationalization may be made as to feed and livestock production:

1. Assuming a normal ratio for grazing computations of 5 sheep or goats to 1 cow or horse there would be 8,000,000 sheep and goats ≠ 5 times 1,125,000 sheep equivalents in terms of horses, cows, donkeys and camels or a gross of 13,625,000 sheep units. With 2,000,000 slaughtered each year this leaves an average of 12,625,000 per year round grazing since little other feed is available.

2. It has been determined by various sources that about 80-90 maunds of dry feed are necessary for one sheep one year. A requirement of 800 # or 80 maunds is used in this calculation.

3. 12,625,000 x 800 = 10,100,000,000 # of feed required on a dry weight basis.

4. Sources are estimated as follows:

1,000,000	acres	valley grass and brush lands @ 1,000 #	=	1,000,000,000 #
250,000	"	wheat stubble & straw @ 1,000 #	=	250,000,000 # 1/
20,000	"	alfalfa @ 2.7 T Avg./Acre	=	108,000,000 #
27,840,000	"	range (used only 0.1 of Registan) @ 315#	=	8,742,000,000 #
		Total required...........................		10,100,000,000 #

(1/ Wheat straw is also used for brick making, fuel and bedding).

5. This seems reasonable until one computes that 30.5#/Acre usable forage is eqv. to 2.54 acres per sheep year long or 0.94 standard A.U.M. (Animal-Unit-Months) per acre. U. S. figures on desert sheep ranges show their grazing capacity as follows: sagebrush grass ranges - 1.6 acres per head per sheep-month, desert shrub ranges - 2.3 and salt desert shrub - 3.6 acres, an average of 2.5 acres/head for one sheep month of grazing. This would indicate 30 acres per head year long. Some Wyoming rangers estimate .10-.25 A.U.M. capacity for desert sheep range.

It is apparent the livestock numbers are too high or the acreage of available range too low. Assuming the livestock numbers are correct, but that the carrying capacity is more nearly 25 acres per head year long, the range acreage required would be 263,437,000 or over three times the total acreage in the watershed. Since this is also unreasonable it is quite likely the true livestock population is much less than quoted above. A more rational solution is offered in lieu of data:

The valley lands, wheat stubble and alfalfa clover pastures can support at

the above rate of dry forage consumption	1,697,000	sheep
The range - 27,840,000 acres at 25/head	1,113,600	"
10% of higher areas at same rate	189,400	"
Total	3,000,000	"

Now converting percentage-wise back to the livestock described in the Ministry's report we estimate approximately 2,000,000 sheep and goats and 250,000 cattle, horses, donkeys and camels in the watershed area of the Helmand sinks.

The ministry of National Economy reported average wool shipments thru Kandahar from A H 1325-1329 as 1310 tons or @ 5# per shear the equivalent of 560,000 sheep; for Afghanistan 4,520 tons or equivalent of 1,810,000 sheep. This is only 7% of the sheep numbers reported or 18% of the number estimated by the rationalization above. In lieu of more factual data the above assumption is used in the computation of the annual values of livestock production shown in TABLE 19 .

D. Summary and Conclusions:

A summary of food products and their values at prevailing market prices is given in TABLE 20 . Using an exchange ratio of 1:42.534 (double the official rate) gives a total annual dollar value of crop production of $24,400,800. To this must be added the value of livestock products of $10,354,800 (see TABLE 19). The total value of annual agricultural production in the entire watershed is computed to be $34,766,600. The per capita value of 985 Afghanis correlates with the Tudor estimate of 1000 Afghanis per capita income for the whole country. Since this region is almost wholly agricultural there would be little additional income from other products. The average laborer's wage or labor income of 3500 Afghanis estimated for 1955 had increased somewhat by 1956 and is now probably 10% higher than the 1955 level. Correspondingly food prices for 1957 are about 20% higher than used in the 1955 prices used for this study. This is the average increase in bazaar prices of 12 basic food items. The general cost of living ratio probably has not shifted materially.

In conclusion, it must be pointed out that these rationalizations may not be truly factual but are the best approach to a reasonable picture of present agriculture in this area. The final relationships of the various factors are kept on a reasonable basis so that exaggerated values do not result to confuse the reader.

Table 19

LIVESTOCK VALUES

(A Rough Estimate of S. W. Afghanistan Livestock Numbers and Annual Value of Livestock Products) *

7/27/57

I **Data:** Afghanistan - (1953 Report of Min. of Agriculture)
25,000,000 sheep and goats (1/5 goats)
5,000,000 Camels, donkeys, horses & cattle
4,000,000 Karakul sheep
8,000,000 Sheep & Goats slaughtered
1,000,000 Hides exported

II Calculations for All Afghanistan using above data:

Item	Unit Value	Quantity	Total Value	Reduced** Quantities For S. W. Afghanistan	Reduced** Values For S. W. Afghanistan
Hides:	Afghanis:				
Sheep	30 each	8,000,000	240,000,000	670,000	20,100,000
Cattle	133 "	250,000	33,250,000	12,500	1,662,500
Camel	177 "	50,000	8,850,000	1,250	221,250
Horse	150 "	25,000	3,750,000	1,250	187,500
Donkey	50 "	25,000	1,250,000	2,500	125,000
		Total Value Hides	287,100,000	—	22,296,500
Wool:	60 Md.	15,000,000 x 0.5 Md. =	450,000,000	600,000	18,000,000
(Note: Wool expt. 1947-1951, 5-Yr. Avg.)			(54,252,000)	(261,800)	
Meat, Eggs, Milk & Cheese:					
Beef	40 Md.	250,000 x 30 Mds. =	300,000,000	1,600	1,920,000
Mutton	50 "	3,000,000 x 30 " =	600,000,000	135,000	27,000,000
Sheep	70 "	5,000,000 x 4.5 " =	1,575,000,000	535,600	168,714,000
Sheep Fat	116 "	5,000,000 x 1.0 " =	580,000,000	535,600	62,129,600
Chicken	27 Ea.	5,000,000 (ea.) =	135,000,000	600,000	16,200,000
Eggs	0.74 "	240,000,000 " =	177,600,000	20,000,000	14,800,000
Cheese	16 Md.	2,000,000 Mds. =	32,000,000	240,000	3,840,000
Milk	13.0 "	24,000,000 " =	312,000,000	2,000,000	26,000,000
	Total Meat, Eggs, Milk & Cheese		= 3,711,600,000	—	320,603,600
Animal Hire:					
Camels	6 Af/mile	x 100,000 x 250 mi. =	150,000,000	5,000	7,500,000
Donkey	5 "	x 500,000 x 100 " =	250,500,000	25,000	12,500,000
Horse	6.5 "	x 100,000 x 300 " =	200,000,000	5,000	10,000,000
Ox Tm.	40 "day	x 500,000 x 50 days =	1,000,000,000	25,000	50,000,000
	Total Value Animal Hire		= 1,600,000,000	—	80,000,000
	Gross Annual Afghani Value Of Livestock Products		6,048,700,000	—	440,900,100
	$ Value @ 21.267 = $1.00		$ 284,417,100	—	$ 20,731,650
	$ Value @ 42.534 = $1.00		$ 142,208,500	—	$ 10,365,825

* Excludes Karakul sheep grown in Northern & Eastern Afghanistan

** Based on relationship of available feed to animal requirements and the acreage and carrying capacity of range lands in S. W. Afghanistan.

Table 20

ESTIMATED PRESENT PRODUCTION AND VALUE OF CROPS GROWN IN S. W. AFGHANISTAN 1/

7/27/57

Crop	Yields in Tons	Price in Afghanis/Md.	Conversion Af/$ 42.534:1	Gross Value in Dollars
Wheat	205,360	12	.02351	11,587,230
Corn & Other Grains	96,610	8	"	6,645,370
Rice	1,370	24	"	154,600
Fruits (Consumed)	26,335	10	"	1,238,270
" (Exported) raisins	6,604	80	"	2,484,160
" " grapes	4,250	15	"	299,750
" " dried fruits	1,303	60	"	395,700
" " fresh "	3,824	10	"	179,800
Vegetables (Consumed)	87,000	3	"	1,227,220
Lentils "	80	14	"	5,270
" (Exported)	18	19	"	1,520
Nuts (Consumed)	45	90	"	19,040
Potatoes (Consumed)	1,100	10	"	51,720
2/ Poppy seed (Exported)	68	50	"	15,990
Alfalfa seed "	21	10	"	990
2/ Tobacco "	95	45	"	20,100
3/ Cotton "	153	80	"	57,400
2/ Cumin "	71	(50)	"	16,690
TOTAL ALL CROPS	434,307			$ 24,400,820
AVERAGE ALL CROPS	0.546 Tons/Acre		$ 56.18/Tons = $ 30.69/Acre	

1/ Estimates based on ratio of population and food consumption to available acreage and present production levels. Export data included where available for A H 1947-'51

2/ Local consumption not estimated. Shipments through Herat, Chaman & Kabul not available on exported items.

3/ Cotton estimated at 1/10 of Afghanistan exports.

NOTE: This is 16.4 % of the value of national agricultural products for 1953-'54 as shown in the Tudor Report.

It has been necessary in arriving at these final figures to:

1. Reduce the previously estimated population of 3,000,000 to 1/2 or 1,500,000.

2. Reduce the livestock population previously estimated at 8,000,000 sheep and goats and 1,125,000 other livestock to about 1/4 or 2,000,000 sheep and goats and 250,000 other animals.

3. Increase the total presently cropped acres by 1.89 times the 1955 estimate made for the Helmand-Arghandab development area.

4. Increase the estimate of average grain yields to the equivalent of 15 bushels of wheat per acre.

A summary of crop production and crop values from all U. S. Federal Reclamation projects for the year 1955 is included for comparison. It will be noted that the present level of gross crop income per acre of the Helmand area is only 1/17 that of the Coachella Valley and 1/8 that of the average of all districts in S. W. Arizona and Southern California (areas of similar climate). The Columbia Basin Project, a relatively new area with about 150,000 acres cropped in 1955, had nearly 4 times the gross per acre value of crops produced as did the Helmand Valley.

It is not expected because of soils and other limitations that the average production of Helmand Valley development areas will reach the above levels. The potential development both in acreage and per acre yields is considerable, however.

If attention is paid to increasing the efficiency of farm production and diversifying crops, rather than to increasing acreages under wheat, it should be possible to produce the wheat required on about 1/2 of the present acreage. This would require an increase to a 25.0 bushel average. The 1955 irrigated wheat in all Federal reclamation projects of the U. S. averaged 42 bushels per acre. The balance of the wheat lands could be released for producing other crops which would in turn help to balance food production against food requirements and gradually provide a more favorable diet and living standard for the population.

March 7, 1957

Table 21

CROP PRODUCTION AND CROP VALUES
FEDERAL RECLAMATION PROJECTS - 1955 1/

Crops	Unit	Per Acre Yields (1955)	Average Value Per Unit 1955 (Dollars)	Gross Crop Value Per Acre 1955 (Dollars) 2/
Barley	Bu.	36.7 - 59.1	1.03	37.80 - 60.87
Wheat	Bu.	34.7 - 50.1	1.78	61.77 - 89.18
Alfalfa Hay	Ton	2.8 - 5.6	21.98	61.54 - 123.08
Pasture	AUM	3.9 - 10.6	4.23	16.50 - 44.84
Sugar Beets	Ton	15.5 - 20.3	9.67	149.89 - 196.30
Cotton	Bale	1.4 - 1.6	173.09	242.33 - 276.94
Beans, dry	Cwt.	15.9 - 17.0	5.24	83.32 - 89.08
Potatoes, late	Bu.	175.3 - 327.6	1.10	192.83 - 360.36
Tomatoes, Fresh	Lug	134.1 - 476.7	1.20	160.92 - 572.04
Lettuce	Crate	196.7	2.57	504.67
Apples	Cwt.	191.1 - 203.5	3.71	708.98 - 754.99
Peaches	Cwt.	102.8 - 185.0	3.47	356.72 - 641.95
Grapes, Table	Cwt.	90.0 - 147.0	3.50	315.00 - 514.50
Citrus Fruits	Cwt.	204.7 - 223.2	2.53	517.89 - 564.70
Oats	Bu.	40.4 - 60.2	.61	24.64 - 36.72
Alfalfa Seed	Cwt.	1.8 - 5.1	18.00	32.40 - 91.80
Clover Seed	Cwt.	2.4 - 3.4	29.00	69.60 - 98.60
Pea Seed	Cwt.	18.2 - 20.3	4.30	78.26 - 87.29
Onions, dry	Cwt.	339.4 - 404.2	1.50	509.10 - 606.30
Rice	Bu.	62.5	2.25	140.62 *
Potatoes, early	Bu.	422.0 - 513.0	.41	173.02 - 210.33
Apricots	Cwt.	195.4 - 285.0	3.50	700.00 -1000.00 *
Cherries	Cwt.	57.5 - 80.0	12.50	700.00 -1000.00 *
Broomcorn	Tons	0.2	1000.00	2000.00 *
Nuts, Pecans	Cwt.	8.0 - 10.8	125.00	1000.00 -1350.00 *
Corn, Field	Bu.	49.3 - 64.0	1.40	69.02 - 89.60
Squash	Cwt.	97.0	3.00	291.00
Carrots	Ton	19.6	12.00	235.20
Cantaloupes	Crate	242.0	1.08	261.36

* Prices obtained from other sources.

1/ From: "Crop Report and Related Data, Federal Reclamation Projects"; U. S. D. I. Bureau of Reclamation, 8/21/56, Washington, D. C.

2/ Mean crop value per acre for S. W. Arizona and Southern California districts = $242.20. Highest is Coachella Valley district with $531.20 crop value/acre.

1 Lug Tomatoes = 31#, 1 bu. = 53#

1 Crate lettuce = 75# net wt.

1 Crate cantaloupes = Standard Crate = [illegible] cantaloupes, net wt. = [illegible]

III WATER RESOURCES:

1. Surface Water Sources and Quantities.

Water resources of the S. W. Afghanistan Area are its several rivers, fed by snow and rainfall, and potential but unexplored and undeveloped ground water. As stated earlier the Helmand River and its several tributaries, the Dori, Arghastan, Tarnak, Arghandab, Tirin, and Musa Kala Rivers contribute about 5/6 of all the waters which flow toward the Chakansur-Siestan Basins. Considerable study of stream flow and climatic records has already been made and the results reported. 1/

This general report will bring together and summarize the data now available on water resources throughout the basin.

a. The Arghandab System. The Arghandab system includes the Dori to the extreme east, the Arghastan which rises in the hills of Mangiar Range east of Ghazni, the Tarnak rising in the Hazarajat above Jaghori, the Arghandab, principal stream rising in the snowfed ranges northwest of Ghazni and the Kushk-i-Nakhud which rises east of Kajakai in the lower ranges. None of these flow year round except the Arghandab. The streams which rise on the lower watersheds are fed less by melting snows and are more subject to flash runoff from rainfall. It will be shown, however, that they do contribute measurably to the total flow.

The period for which stream flow has been measured includes the water years October, 1947 to date. Since the major flow of the year has past it is possible to present 10 years data, (Table 22), showing an average inflow of over 1,000,000 acre-feet.

The Arghandab-Tarnak water allocation study showed 795,000 acre-feet release adequate for irrigation of the lands available for development in the Tarnak-Arghandab Area. On this basis 7 of the 10 years show ample flow and three years 60-72% of that required. The low years occured singly thus allowing carryover storage to partially offset the water shortage. A correlation of rainfall and runoff made in the above report showed that this relationship could be extended reasonably safely to include all years for which rainfall data was available. This gives a 19-year record in which only 5 of 19 years or 26.3% fall short of full supply. Again these low years occured singly. It was shown in the study of water allocations that with the reservoir carryover normally possible 96% of the full acreage can be cropped even in the dry years by eliminating double-cropping with high use summer crops. Chart L. D. 132 summarizes the Arghandab water use picture.

The Arghastan and Tarnak Rivers pass through considerable areas of cultivated lands in their upper and central reaches, consequently are completely utilized during normal to low flow. The Dori serves cultivated acreage but also has a smaller drainage area.

In order to estimate the contributions of the streams to waters passing through the Tarnak-Arghandab projects an analysis is made of flow past Kala Bist,

1/ Reconnaissance Soils & Drainage Survey and Land and Water Development Potentials, Chakansur Area, MKA, Oct., 1955.
A Study of Arghandab-Tarnak Water Allocations, MKA, July, 1956.

TABLE 32 INFLOW MEASUREMENTS - ARGHANDAB DAM*

Re-revised: June 2, 1957

MONTH	WATER YEAR 1947-1948	1948-1949	1949-1950	1950-1951	1951-1952	1952-1953	1953-1954	1954-1955	1955-1956	1956-1957	AVERAGE LOW YEARS	AVERAGE HIGH YEARS	10 YRS. AVERAGE ALL YEARS	AVERAGE INFLOW CFS
OCT.	9,540	13,500	19,740	23,780	20,980	21,030	13,250	29,227	12,530	36,740	19,930	20,075	20,032	323
NOV.	15,900	22,190	26,236	32,330	28,290	27,980	21,120	28,120	19,770	45,200	24,000	27,[illegible]	25,514	442
DEC.	32,020	29,510	30,740	39,870	36,740	31,630	27,440	41,830	50,700	43,190	35,160	36,884	36,367	589
JAN.	24,240	30,820	95,280	38,780	39,650	31,150	44,850	41,480	45,160	93,960	32,290	55,500	48,537	783
FEB.	24,410	34,740	70,160	47,520	68,750	93,550	189,600	33,100	71,000	119,490	50,350	85,695	75,232	1,342
MAR.	145,800	293,400	135,900	144,300	161,400	109,300	302,000	109,800	355,500	354,820	121,630	249,620	211,220	3,407
APR.	185,900	271,100	326,800	262,200	242,100	79,400	339,000	63,490	536,000	697,000	109,600	382,049	300,300	5,006
MAY	76,250	92,640	285,900	302,100	111,370	46,360	228,000	61,560	189,100	(201,000)**	61,390	201,445	159,430	2,572
JUN.	26,420	32,730	74,830	80,290	37,910	28,860	74,000	25,100	66,300	(60,900)	26,790	60,995	50,735	846
JUL.	14,680	17,570	35,420	34,010	27,930	10,050	45,900	9,460	233,000	(35,000)	11,400	61,260	46,300	747
AUG.	9,990	21,990	25,110	20,920	22,950	7,060	22,900	7,500	64,600	(25,000)	8,180	29,070	22,800	368
SEP.	5,860	10,780	18,860	18,800	18,340	7,460	20,017	5,620	30,200	(19,500)	6,310	19,500	15,545	259
TOTALS	571,010 (L)	870,970 (H)	1,144,976 (H)	1,044,900 (H)	816,410 (H)	493,830 (L)	1,328,077 (H)	456,287 (L)	1,673,860 (H)	1,729,800 (H)	507,030	1,229,883	1,013,012	1,388

* Inflow quantities for Arghandab Dam -- I.C.A. Records.

** May-Sept., 1957, extrapolated.

Seasonal Distribution - Low Years: Dec-May = 410,420 or 81% and June-Nov. = 96,610 or 19%; High and Normal Years: Dec-May = 1,011,390 or 82% and June-Nov. = 218,490 or 18%. March-April-May - 58% of inflow in dry years and 68% inflow in wet or normal years.

4. Map folios containing the soils and drainage surveys and interpretative or classification maps for use in project development.

Only the first two will be prepared for general distribution. The appendices and folios will be retained in a central file for reference and only such reproductions made as are needed by agencies engaged in development work in a specific area.

where the Arghandab enters the Helmand, and the inflow at Arghandab. First the annual crop usage was computed from the plant water use relations already established and from crop acreages as determined by soils and aerial surveys and field estimates. An overall irrigation efficiency of 40% and delivery losses of 25% were assumed. Return flow was assumed to account for only 5 % of water use. The estimated irrigation use by crops is given in Table 23.

The monthly outflow records at Arghandab and Kala Bist were compared for the years 1950 to 1957. The total flow past Kala Bist was 96.3% of the computed outflow past Arghandab. When the estimated crop usage and evaporation losses were considered in the study it appeared that over 500,000 acre-feet more water leaves the Arghandab area annually than can be accounted for by the Arghandab flow alone. This may be then the average annual contribution of record of the Dori-Arghastan-Tarnak system, and the Khushk-i-Nakhud and other smaller streams. These data shown in Table 24, show that the method of computation accounts for all but 5.6% of the total water entering at Arghandab, passing Charbarburjak and used by crops. The total annual watershed yield of the Arghandab and its tributaries available for development within the project areas appears therefore to be in the neighborhood of 1,500,000 acre-feet.

b. The Helmand System. An 11-year record of flow for the Helmand is given in Table 25. The 1946-1947 record is not a measurement at Kajakai. The last three months of 1957 water year are interpolated. From these date it can be seen that the Helmand flow ranges from as low as 2,112,000 acre-feet to as high as 8,840,000 acre-feet with 5,100,000 being about the average. In the Chakansur Study an attempt was made to evaluate the flow over a longer period of time. The Perso-Afghan Arbitration Commission Report of 1905 contained a combined estimated and measured discharge record of 30 years from 1872-1901. To this, in Table 26, was added the 11 years of records for 1946-1957, after subtracting the very unusual flood period of 1883. The 41-year record thus computed gives the average flow as slightly less than 5,000,000 acre-feet.

In 1952, Stanley and Charles of MKA made a boat trip down the Helmand from Girishk to Kwabgah during which they recorded all existing diversions estimating their capacity and measuring the intake at the time. Some 63 diversions were reported, 14 of which were not operating and 8 were in disrepair and unusable. The combined capacity at the intakes was estimated at 3,748 cusecs. A total of 81 diversions appear on aerial photos from Kajakai down stream. At the above average this amounts to 4,473 cusecs total combined diversion capacity or enough to divert 277,000 acre-feet per month at full use. Actual diversion may be 25-75%.

Studies made by means of soil surveys, aerial photos and local census indicate that per acre-month diversion requirement by crops and total crop acreages are about as indicated in Tables 27 and 28. From these data a study is made, similar to that for the Arghandab, comparing outflow at Kajakai and flow past Charbarburjak with estimated crop use and evaporation losses. The summation of flow from Helmand and other sources when computed monthly and compared with estimated crop and evaporation losses accounted for all but 0.9% of the total water. Table 29, shows that about 1,250,000 acre-feet of water enters the Helmand in addition to that measured at Kajakai. It has already been shown in Table 24, that approximately 1,000,000 acre-feet was entering at Kala Bist from the Arghandab.

TABLE 23 ARGHANDAB RIVER WATER USE 7/24/57

Estimated Water Use by Crops, 1950-1957*

MONTH	GROSS DEMAND 1950 A/F	1951	1952	1953	1954	1955	1956	1957
Jan.	19,600	19,600	19,600	19,600	22,343	22,343	27,260	27,260
Feb.	18,600	18,600	18,600	18,600	21,377	21,377	26,080	26,080
Mar.	34,920	34,920	34,920	34,920	43,014	43,014	52,480	52,080
Apr.	66,410	66,410	66,410	66,410	76,331	76,331	93,125	93,125
May	75,670	75,670	75,670	75,670	86,981	89,981	106,115	106,115
June	26,370	26,370	26,370	26,370	30,308	30,308	36,975	36,975
July	27,285	27,285	27,285	27,285	31,363	31,363	38,260	38,260
Aug.	23,485	23,485	23,485	23,485	26,993	26,993	32,930	32,930
Sept.	9,975	9,975	9,975	9,975	11,465	11,465	13,990	13,990
Oct.	3,540	3,540	3,540	3,540	3,560	4,047	4,074	4,970
Nov.	17,815	17,815	17,815	17,815	17,815	20,479	20,479	24,985
Dec.	37,770	37,770	37,770	37,770	37,770	43,416	43,416	52,970
TOTAL	361,440	361,440	361,440	361,440	409,300	421,117	495,194	509,740
ESTIMATED CROP ACRES	85,000	85,000	85,000	85,000	95,000	98,000	115,000	120,000

* Usage calculated on basis of existing crop acreages, 25% delivery losses, 60% irrigation losses and 5% use of return flow.

TABLE 24 7/20/57

A STUDY OF WATER FLOW RECORDS AT ARGHANDAB AND KALA BIST WITH REFERENCE TO CROP USE AND SOURCES OF WATER 1/

Year	At Arghandab Reservoir Inflow	At Arghandab Reservoir Outflow	Flow Past Kala Bist	Annual Excess of Kala Bist over Arghandab	Estimated Crop Usage	Difference of Arghandab Release and Crop Usage	Calc. Flow from Other Sources
1950	1,158,105	No Record	1,558,443	622,521	361,440	796,665	810,933
1951	1,054,721	No Record	555,350	1,485	361,440	693,281	51,775
1953	493,830	590,400	205,310	82,150	361,440	228,960	119,400
1954	1,328,077	1,137,820	1,396,310	406,290	409,300	728,520	866,873
1955	466,287	591,346	148,691	----	421,117	170,229	90,729
1956	1,673,360	1,488,650	1,731,510	408,720	495,194	993,456	802,061
7 Mo. 1957	1,728,900	1,782,670	1,960,000*	600,000*	509,740	1,272,930*	800,000* 2/
Totals	7,903,280	7,803,712	7,555,614	2,121,166	2,919,671	4,884,041	3,541,771
Avg.	1,129,040	1,114,816	1,079,516	303,024	417,097	697,720	505,967

* Estimated by comparison with similar years.

1/ The first three columns of data are from ICA-MKA records. The crop use estimate is based on crop acreage measur from soils and aerial surveys. Consumptive use tables for the crops grown are those computed in the report on Arghandab-Tarnak Water Allocations, July 1956.

2/ Approximately 92,600 Acres of water is not accounted for after subtracting 31,500 for reservoir evaporation loss This amounts to about 5.6% of the total.

TABLE 27

July 3, 1957

ESTIMATED WATER USE IN HELMAND VALLEY
(Kajakai to Rudbar)
(Total Diversion in Acrefeet/Acre by Crops)

	Orchards 1/3 ≠ Vineyards 2/3	Wheat and Other Grains	Alfalfa Pasture	Evapotranspiration losses from brush, grass & trees	Summer Crops
January	0.055	——	0.137	0.042	——
February	0.158	——	0.212	0.062	——
March	0.313	0.537	0.625	0.189	——
April	0.313	1.000	1.238	0.375	——
May	0.900	1.350	1.600	0.483	0.575
June	1.087	——	1.938	0.583	0.625
July	1.225	——	2.088	0.625	1,375
August	1.025	——	0.838	0.250	1.250
September	0.663	——	1.325	0.400	1.013
October	0.313	0.413	1.125	0.337	0.838
November	0.250	0.637	0.688	0.208	——
December	0.187	0.137	0.350	0.104	——
Years	Acres in Each Type of Crop				
1948-1950	20,000	50,000	550	100,000	10,000
1951	"	52,000	700	"	"
1952	"	56,000	2,050	"	11,300
1953	22,500	75,000	7,500	"	29,000
1954	25,000	80,000	9,000	"	30,000
1955	"	100,000	9,500	"	"
1956	"	105,000	10,000	"	"
1957	"	"	"	"	"
Uc	33"	18.5"	55"	44"	25"

TABLE 28 — HELMAND RIVER WATER USE — July 3, 1957

1948-1957 - ESTIMATED WATER USAGE, KAJAKAI TO RUDBAR, IN ACRE-FEET*

MONTH	GROSS DEMAND 1948-1950 A/F	1951	1952	1953	1954	1955	1956-1957
January	5825.00	5850.00	6031.25	6937.50	7300.00	7368.75	7437.50
February	10117.50	10150.00	10437.50	12000.00	12725.00	12831.25	12937.50
March	53898.75	55067.50	58061.25	72461.25	76874.50	87930.00	90930.00
April	97431.25	99612.50	105287.50	131812.50	139450.00	160068.75	165687.50
May	144325.00	147262.50	155575.00	202375.00	214350.00	242150.00	249700.00
June	92065.00	9[illegible]375.00	95787.50	120125.00	126375.00	127343.75	128312.50
July	106900.00	107212.50	111812.50	150593.75	158162.50	159206.25	160250.00
August	88812.50	88937.50	91693.75	120943.75	126012.50	124431.25	126850.00
September	67300.00	67500.00	70612.50	97406.25	102062.50	102725.00	103387.50
October	72325.00	36862.50	77575.00	107143.75	112512.50	121325.00	123950.00
November	59750.00	61125.00	64612.50	81093.75	85937.50	95031.25	102562.50
December	22062.50	22400.00	23418.75	28406.25	31087.50	33012.50	33875.00
TOTAL	823812.50	833805.00	873905.00	1134298.75	1194842.50	1282423.75	1308880.0
ESTIMATED CROP ACRES	80550	82700	89350	134000	144000	164500	170000

* Usage includes crop use at estimated overall efficiency of 35%, plus evapo-transpiration losses from 100,000 acres of brush trees and grass along river valley. See Table 27 for crops, crop acres and consumptive use.

TABLE 29 7/20/57

A STUDY OF HELMAND RIVER FLOW AT KAJAKAI AND CHARHARBURJAK WITH REFERENCE TO CROP USE AND SOURCES OF WATER 1/

Year	At Kajakai Reservoir Inflow Acre-feet	At Kajakai Reservoir Outflow Acre-feet	End-of-Mo. Stor. Acre-feet	Flow Past Charharburjak Acre-feet	Sum of Mo. Excess Flow at Charharburjak	Crop & Other Veg. Uses	Diff. of Kajakai Release & est. Crop Use	Calc. Flow of Water from Other Sources
1949	5,212,413	No Record	No Record	5,422,879	689,109	820,810	4,391,598	1,107,322
1950	5,077,277	No Record	No Record	6,072,312	1,569,704	820,810	4,256,462	2,055,869
1951	6,185,300	No Record	No Record	5,645,380	111,500	828,103	5,357,192	498,933
1952	4,816,400	No Record	No Record	4,186,000	49,400	825,682	3,990,709	429,627
1953	4,086,900	3,393,000	530,621	2,554,980	205,500	1,080,207	2,312,785	433,918
1954	5,821,190	5,164,850	932,174	6,384,400	1,702,200	1,179,952	3,984,691	2,408,296
1955	3,761,850	3,774,272	1,061,503	2,886,700	94,600	1,253,588	2,520,675	445,839
1956	6,099,900	6,242,800	1,122,958	6,768,900	1,068,600	1,298,858	4,943,937	1,888,930
1957	7,026,500	5,904,650*	Inc. Rec.	6,555,000*	1,445,000*	1,305,877	4,598,773*	1,955,000*2/
Totals	48,087,730	45,770,962	3,647,256	46,477,051	6,935,613	9,413,886	36,356,822	11,223,444
Avg.	5,343,081	5,085,662.4	911,814	5,164,339	770,624	1,045,987.3	4,037,313	1,247,049

* Estimated by comparison with similar years.

1/ The first four columns are taken from ICA-MKA records. The crop use estimate is based on crop acreage measurements from surveys and aerial photos and average consumptive use tables for the common crops. (See Table 27).

2/ Approximately 58,000 acre-feet of the water, after subtracting an estimated 150,000 for evaporation losses, is not accounted for by the assumptions made. This may be additional irrigation wastage and stream bed losses. It amounts to 0.9% of the total.

The other 250,000 comes from Musa Kala, Sangin, Lui Manda Wash and other small drainageways. The Helmand-Arghandab System has according to the above records a combined output of approximately 7,000,000 acre-feet annually.

The relationship of flows measured at the four gauging stations studied above are shown in Drawing LD-133. From this chart it is evident that in the high years or over 50% of the time there is more water flowing past the outlets of these rivers than passes the damsites. A graphic story of the water use history of the Helmand-Arghandab System from 1949-1957 is shown in Drawing LD-134. Of the total water entering the Arghandab-Tarnak Area 1,000,000 acre-feet has been passing into the Helmand unused. This includes 5 years during which the Arghandab Reservoir was in operation. Of the combined waters of all streams amounting to 7,000,000 acre-feet, four million acre-feet of water annually has poured into the vast inland basins of the Chakansur-Siestan where it has no further value for irrigation use.

c. Other Streams entering the Chakansur-Siestan Basins. Records are few and incomplete for other streams. During high water the roads are impassable. Many times the guaging equipment becomes dislodged or fouled during high flow. Days pass without repair and valuable records are lost. As a consequence many of the high flow periods have gone unmeasured. Such data as is available is summarized in Table 30. These are of little value for estimating water yields. Calculated discharges up to 135,000 cfs on the Farah, 42,000 cfs on the Arghastan and 49,000 cfs on the Khash shows that large volumes of water may pour down these streams at times. The Farah is used for irrigation of large areas. The upper Arghastan also has considerable irrigated land. There are scattered villages and farm land along the Khash between Dilaram and Chakansurak.

A summary is presented in Table 31, of all stream waters in the watersheds of the Chakansur-Siestan Basins. These data are partly from stream gauging records, partly from historical records of the Perso-Afghan Arbitration Commission and partly from correlation of watershed areas and elevations with water yields per unit area. The total indicated is on the order of 12,000,000 acre-feet. It is recognized that not all of this water can be developed for irrigation use. Nevertheless in a desert country where food production is a great national need this water resource is a tremendous asset.

d. Floods and Flood Hazards. The Helmand River flows in a rather confined valley between high bluffs of rock. In places it is 4-5 kilometers wide but at other places the bluffs close in to distances of only 2.25 kilometers. The Chakansur Report studied the floods which affect the basin and included an estimate of flood frequencies. Table XII, of that report is included here as Table 32. The 1903 flood measured by the 1903-'05 Commission had an accumulative flood volume of 5,780,000 acre-feet. The flood frequency graphs show floods of the magnitude of the 1903 flood could occur every 3-5 years. At the bottom of the table is given the total flow past Charharburjak for four years, 1950, 1954, 1956 and 1957 (interpolated). All of these years exceeded the 1903 flood in total volume entering the basin. Flood peaks of twice that magnitude are estimated to occur once in 30 years. More data on flood frequencies and flood volumes are needed to provide a basis for planning river control works to prevent recurrence of such serious damage as took place in 1956 and 1957.

e. Quality of Surface Waters. Laboratory analyses have been made of samples from seven rivers. No monthly sampling to determine quality at all stages

II PHYSIOGRAPHY, CLIMATE AND EXISTING AGRICULTURE

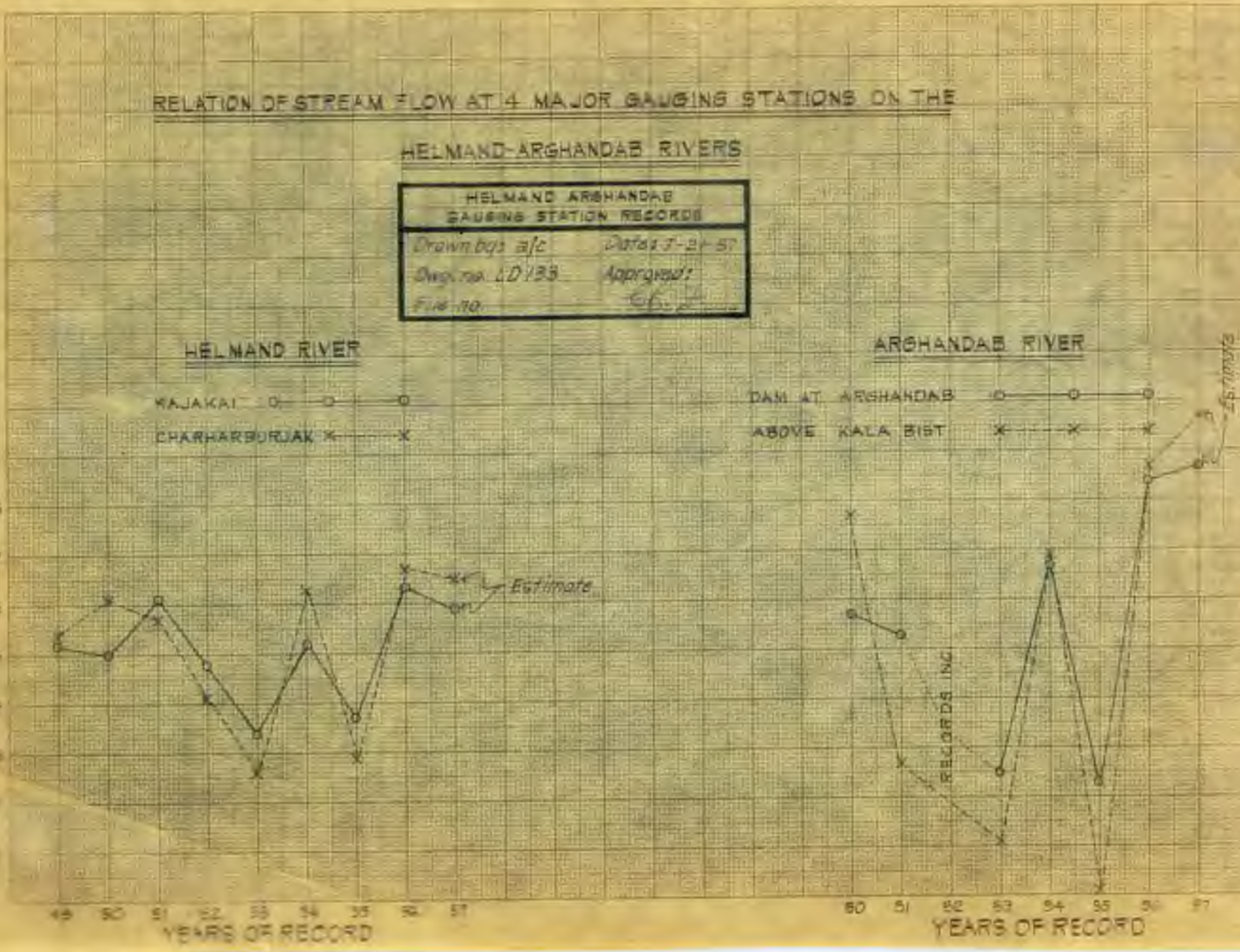
1. Topography and Drainage:

The total land area draining into the Chakansur-Siestan Basins includes the watersheds of several major streams extending to the central divide of the Koh-i-Baba, Parapomisus and Hindu Khush ranges which are westward extensions of the principal Himalayas of South Central Asia. About 1/2 of the watershed areas lie above 1,000 meters and the principal water-yielding slopes are rugged, scantily vegetated mountain ranges rising to over 7,000 meters in the east end and gradually dropping to a crest elevation of 3,000-4,000 meters along the western ranges. The foothills and ranges follow a westerly course and the great outwash fans and plateaus extend southwesterly from these foothills along a course roughly 32° N in the eastern part of the country to 32° 30' north in the western part near Farah. This vast outwash desert is characterized chiefly by its covering of blackened weathered and pitted gravels, scanty covering of shrubs and forbs and grasses, and occasional flats and swales covered with silts of varying depths and more heavily vegetated. The topography of the desert plains is commonly gently rolling to hilly or broken near stream courses. Occasional isolated uplifts of basalts, limestones, granites and schists break the monotonous sweep of the vast desert plains.

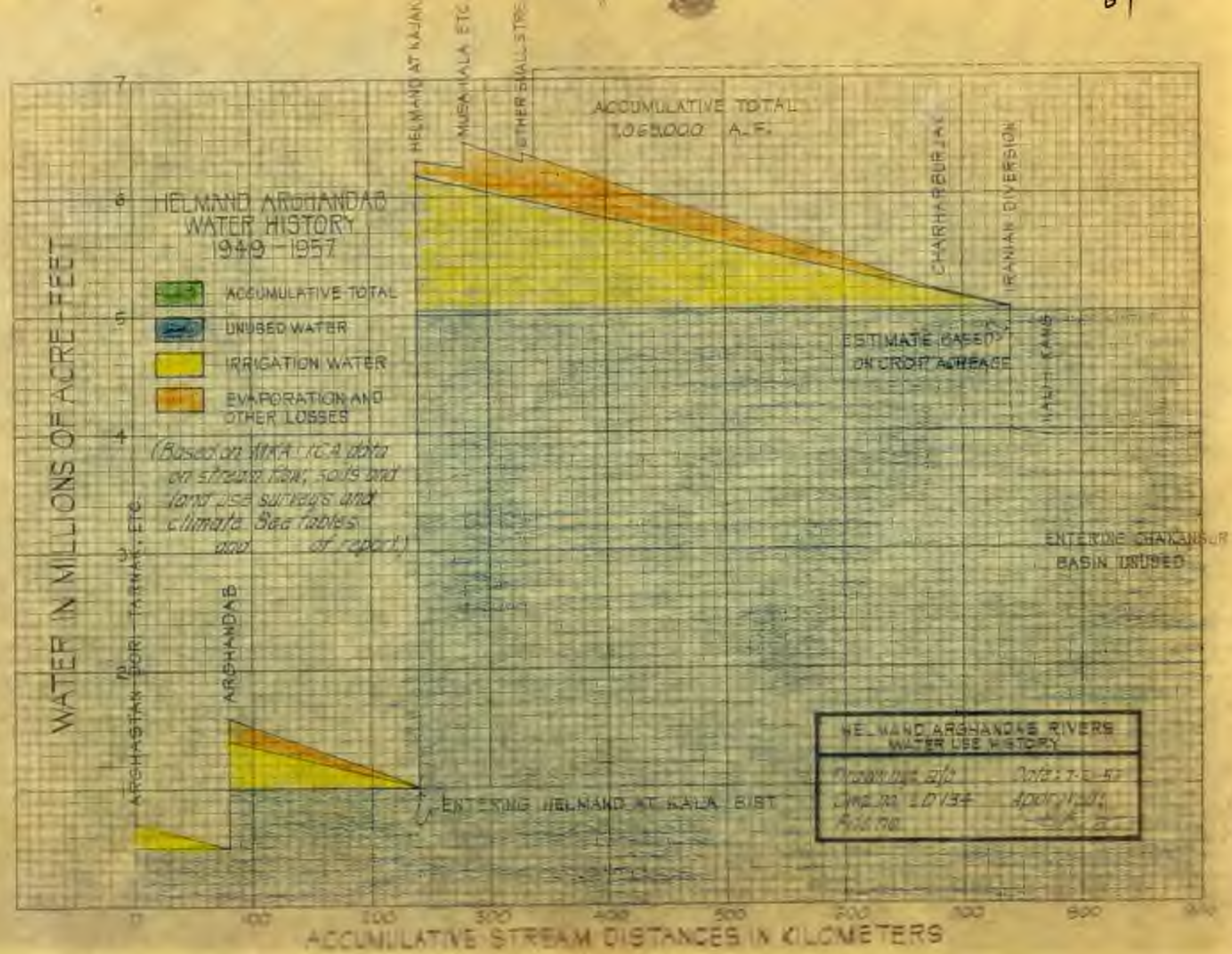
Numerous water courses cross the outwash plains in a generally southwest direction. It is calculated that the combined watersheds cover 139,500 square miles. South of the Helmand and Arghandab, the two largest rivers, lies a vast desert covered in many places with marching sand dunes, commonly it is referred to as the Registan (land of sand). This area of about 40,000 square miles has very few drainage ways and contributes little to the watershed runoff. The lower central desert lying within the great loop of the Helmand called the Dasht-i-Margo also has several thousand square miles with little surface drainage into the Chakansur bound streams. An area of about 6,400 square miles lying in the northeast part at the head of the Arghastan River, drains into an inland salt basin, Lake Abistada, which seldom overflows into the lower stream courses. The Helmand River and its several tributaries drains the eastern two-thirds of the entire watershed area and contribute about 5/6 of all the runoff. These waters are fed year-round by melting snows and rains on the very high and rugged mountains north and west of Kabul, the country's capital. Five other streams discharge directly into the great inland basins which lie at the southwest border of the country. The boundary between Iran and Afghanistan passes through the center of this series of flat, shallow basins. Of these five streams only the Khash, Farah and Harud have sufficient flow to be of any value for irrigation development. All the runoff of S. W. Afghanistan, except for minor areas in the extreme southeast part of the Registan, drains into these great inland basins referred to in Afghanistan as the Chakansur and in Iran as the Siestan. This series of lakes, lake terraces and eroded lake benches occupy some 9,000,000 acres of land. The general elevation is about 500 meters. One large sink, called the Gaud-i-Zirreh, lying south of the extreme southwest loop of the Helmand is 200-300 feet lower than the remainder of the basins. Waters reach it in major floods only, however the capacity estimated at 30,000,000 acre-feet was reported nearly filled in the flood of 1883.

2. Climate:

Climatic records of long duration are almost unknown in this area. Quetta in Pakistan has the longest records but is so situated that its data is relatively inapplicable to the Southwest Afghanistan areas. The Afghan Meteor-



RELATION OF STREAM FLOW AT 4 MAJOR GAUGING STATIONS ON THE
HELMAND-ARGHANDAB RIVERS
HELMAND ARGHANDAB
GAUGING STATION RECORDS
Drawn by: a/c
Date: 3-21-57
Dwg. no. LD 133
Approved:
File no.
HELMAND RIVER
KAJAKAI
CHARHARBURJAK
ARGHANDAB RIVER
DAM AT ARGHANDAB
ABOVE KALA BIST
Estimate
Estimate
RECORDS INC.
FLOW IN MILLIONS ACRE FEET
FLOW X 100,000 ACRE FEET
YEARS OF RECORD
YEARS OF RECORD



HELMAND ARGHANDAB
WATER HISTORY
1949 - 1957
ACCUMULATIVE TOTAL
UNUSED WATER
IRRIGATION WATER
EVAPORATION AND OTHER LOSSES
(Based on HVA - ICA data on stream flow, soils and land use surveys and climate. See tables of report.)
ACCUMULATIVE TOTAL
7,065,000 A.F.
HELMAND AT KAJAKI
MUSA KALA, ETC.
OTHER SMALL STREAMS
CHAHAR BURJAK
IRANIAN DIVERSION
ESTIMATE BASED ON CROP ACREAGE
ENTERING CHAKANSUR BASIN UNUSED
ARGHASTAN, DORI, TARNAK, ETC.
ARGHANDAB
ENTERING HELMAND AT KALA BIST
WATER IN MILLIONS OF ACRE-FEET
ACCUMULATIVE STREAM DISTANCES IN KILOMETERS
HELMAND ARGHANDAB RIVERS
WATER USE HISTORY

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Table 30

7/22/57

SUMMARY OF STREAM FLOW DATA FOR OTHER STREAMS 1/

Year	Arghestan 6620 Sq. Mi. Acre-Feet	Farah 10,400 Sq. Mi. Acre-Feet	Ghazni 495 Sq. Mi. Acre-Feet	Khash 2030 Sq. Mi. Acre-Feet	Musa Kala 1450 Sq. Mi. Acre-Feet
1949	—	—	—	—	—
1950	— —	— —	(242) 49,460	— —	— —
1951	— —	— —	(454) 65,140	— —	— —
1952	— —	— —	(317) —	— —	— —
1953	(11,100) 2/ 74,792	(127,000) 794,392	— —	(26,700) 146,600	(6,620) 98,870
1954	— —	(68,000) —	— —	(9,380) 395,410	(7,600) 181,511
1955	(2,780) 14,662	— —	— —	(49,000) 330,716	(38,000) 100,847
1956	410,004	—	—	—	—
1957	—	—	—	—	(71,000)
Totals	494,458	—	114,600	872,726	381,228
cfs Max. Discharge	42,100-2/13/54	135,000-3/18/55	454-5/6/51	49,000-3/15/55	71,000-3/17/57
Average of Above	167,000	—	57,300	290,908	127,076
Runoff Inches	.473"	1.43"	2.17"	2.62"	1.64"

1/ These are mostly from ICA records. Difficulties of travel and maintenance of equipment have been such that there are very few complete records. High flows are often not measured because of equipment damage and inaccessibility for repair.

2/ Maximum discharge in cubic feet per second.

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Table 31 GENERAL ESTIMATES OF DISCHARGE OF STREAMS EMPTYING INTO CHAKANSUR BASIN WITH [illegible] AVAILABLE SOURCE DATA

WATERSHED	AREA SQ. MILES	EST. ANNUAL RUNOFF (in.)	NORMAL RUNOFF PERIOD	EST. PEAK RUNOFF CUSECS	ANNUAL YIELD ACRE/FEET	EST. IRR. POTENTIAL USE ABOVE BASIN ACRE/FT.	[illegible]T. [illegible]USED [illegible]ENT	EST. PEAK FLOOD DISCHARGE INTO THE BASIN CUSECS-MONTH
Helmand (total)	107,169	1.23	Annual	600,000	7,302,000			215,000
Helmand Above Kajakai	15,573	6.07 (1)	Annual	200,000	5,044,943	2,732,300 (5)	[illegible]%	
Arghandab (total)	7,549	3.00	Annual	—	1,216,000	All	[illegible]low past	—
Arghandab Above Dam	5,900	3.62 (1)	Annual	—	1,129,400	All	[illegible]ala Bist)	—
Arghandab Below Dam	1,649	1.00	Jan-Mar	—	87,000	All	[illegible]%	—
Tarnak	3,321	1.50	Feb-May	—	260,000	All	[illegible]%	—
Arghastan	5,780 (2)	1.00	Feb-May	42,000	300,000	All	[illegible]%	—
Dori	3,285	1.00	Feb-May	—	175,000	Unknown	—	—
Helmand Below Kala Bist	6,363 (3)	0.25	Feb-April	—	85,000	None	[illegible]11	—
Dasht-i-Margo	9,518 (3)	0.15	Feb-April	—	75,000	None	[illegible]11	—
Chah Baigi	1,180	0.15	Feb-April	—	10,000	None	[illegible]11	—
Hud-i-Khar	682	0.15	Feb-April	—	5,000	None	[illegible]11	100
Khuspas	1,607	0.50	Feb-April	3,500	60,000	50%	[illegible]0%	2,000
Khash	5,183	1.73 (4)	Jan-June	49,000	480,000	All	[illegible]0%	22,500 (4)
Farah	10,624	3.43 (4)	Jan-June	135,000	950,000	60%	[illegible]0%	100,000 (4)
Harud	13,072	1.02 (4)	Feb-June	45,000	710,000	Unknown	[illegible]0%	45,000 (4)
Musa Kala	2,580	2.00	Jan-June	71,000	275,000	85%	[illegible]0%	—
Sanguin	3,000	1.00	Feb-May	—	160,000	10%	[illegible]5%	—
TOTAL FOR AFGHAN BASIN	139,537	1.63"	—	—	12,063,000	—	—	384,600

NOTES:
(1) Helmand and Arghandab above dams based on watershed above dam and 10 yrs. inflow records.
(2) Area of 6,437 sq. miles - above Lake Ab-i-Istada is excluded.
(3) An estimated 44,056 sq. miles of Registan and Dasht-i-Margo do not contribute to runoff.
(4) Calculated from data in Perso-Afghan Arbitration Commission Report of 1905.
(5) Based on Soil Surveys and excluding Dasht-i-Bakwa and Khash Rud Areas.

Table 32 ANALYSIS OF ACCUMULATIVE FLOOD VOLUMES IN 1903 FLOOD ACRE/FEET # Revised 7/22/57

DATES	Acc. Vol. Helmand	Acc. Vol. Other Streams	Total Acc. Vol. 1 & 2	Evap. Rates Feet/Day	Acc. Evap. and Perc. Losses	Est. Acc. Net Water Use (Irr.)	Balance of Water Volume in Hamuns
Jan.	150,000	---	150,000	Jan - .007	716	24,500	124,784
Feb.	---	---	250,000	Feb - .004	1,158	49,000	199,842
Mar.	530,000	225,000	755,000	Mar - .007	2,304	73,500	679,196
Apr.	2,071,950	1,341,300	3,413,200	Apr - .027	10,794	98,000	3,304,406
5/1-5/10	3,089,790	1,994,980	5,084,570	May - .036	168,243	121,990	4,794,337
5/11-5/20	3,811,890	2,459,180	6,271,070	---	401,818	48,133	5,739,129
5/21-5/31	4,351,990	2,806,384	7,158,374	---	722,739	48,133	6,297,379
6/1-6/10	4,751,050	3,062,924	7,813,974	Jun - .055	1,043,661	46,388	6,623,925
6/11-6/20	5,025,250	3,329,184	8,354,434	---	1,396,736	48,133	6,949,565
6/21-6/30	5,224,450	3,338,784	8,563,234	---	1,724,211	48,133	6,830,890
7/1-7/10	5,353,110	---	8,691,894	Jul - .080	2,106,266	170,786	6,414,842
7/11-7/20	5,429,130	---	8,767,914	---	2,533,069	48,133	6,226,712
7/21-7/31	5,480,852	---	8,819,636	---	2,951,066	48,133	5,860,437
8/1-8/10	5,519,412	---	8,858,196	Aug - .053	3,378,278	195,184	5,284,734
8/11-8/20	5,561,112	---	8,899,896	---	3,658,957	46,133	5,232,806
8/21-8/31	5,584,366	---	8,923,150	---	3,952,230	48,133	4,962,787
Sep.	5,607,946	---	8,946,730	Sep - .020	4,294,349	219,582	4,432,799
Oct.	5,643,844	---	8,982,628	Oct - .007	4,475,187	243,398	4,264,043
Nov.	5,706,364	---	9,045,148	Nov -(.006)	4,678,042	268,378	4,098,728
Dec.	5,780,578	---	9,119,362	Dec - .002	4,827,034	292,778	3,999,550
1950	6,072,812	These are measured flows at Charharburjak in the years shown. By comparison it can be seen that serious flooding of the lower basins can occur with rather high frequency.					
1954	6,384,400						
1956	6,768,900						
1957	6,555,000						

Reference - Statement C, Table 6, Volume 2 of the 1903-'05 Perso-Afghan Arbitration Committee Report.

* 1957 inflow is interpolated from May thru September.

of flow has been made, however. This type of study is needed on streams which drop to very low flow stages and where the waters are not mixed by controlled impounding and release. The Arghastan for example flows through a very saline area and karezes tapping the stream bed underflow carry excessive salts and alkali for irrigation of these moderately heavy soils. In high flow the Arghastan water is of usable quality. Table 33, gives the summary results of laboratory analyses of waters from the several streams. It will be noted that the Helmand, Arghandab and Khash carry waters of excellent quality. The other streams carry more saline waters but still of quality suitable for irrigation. The more favorable calcium-sodium ratio makes the waters of the Helmand and Arghandab valuable for reclamation of saline-alkali lands.

f. Quality of Ground Waters. Little information is available on the quantity of ground water available for irrigation use. Three wells drilled near Kandahar have obtained artesian flow at 200'-300'.

One 235' artesian well pumped at full capacity of 4" pump for 24 hours showed a drawdown of 66' but recharged to within 2 feet of ground surface within 45 minutes after stopping the pump.

The quality of ground water from various localities has been tested in the MKA laboratory. The results of these analyses are summarized and included in the appendices to the area reports. A summary classification of the various waters is included in Table 34. From this table it is noted that several of the wells and karezes yield water which is unsatisfactory for irrigation use or domestic use. Long irrigation of deep, silty soils of the lower central Tarnak Area has resulted in severe saline-alkali soils over large tracts. Sources of water classed as C3 or S3 are unsatisfactory for any but very permeable, well-drained soils. Extra water must be applied to maintain a salt balance permitting growth of crops. C4 or S4 water should not be used for irrigation. C4 water may be used for certain special crops on highly permeable, freely-drained soils. Some of the wells dug at the various camps have been unsatisfactory for domestic or industrial use because of high salts which render the water unfit to drink or extreme hardness, making the water unsuitable for laundry and boiler use without treatment. The table shows that of the 29 wells examined, 3 are of good quality, 13 fair and 14 poor to unsatisfactory for domestic and industrial use. Of both wells and karezes 21, or 57% were fair to poor and 16, or 43%, poor to unsatisfactory for irrigation use because of salts. Seven were very poor to unsatisfactory because of high alkali hazard if used for irrigation.

g. Present Status of Water Control. The Arghandab Reservoir holds 390,000 acre-feet, about 300,000 active storage or 35% of inflow. By careful regulation and use and choice of crops, up to 90% of inflow can be diverted to irrigation. Wider range in regulations and with assurance of ample water in low inflow years could be had by another 250,000 acre-feet of storage making 60% total inflow subject to storage. There is a power potential of 9500 kw for 7 months and 2500-6000 kw for 5 months.

The Kajakai Reservoir holds 1,490,000 acre-feet now but with the spillway gates installed should hold 2,600,000 acre-feet. The maximum release is 8,500 cusecs.

Table 33 SUMMARY OF SURFACE WATER RESOURCES 7/30/57

Location	Arghandab River	Arghastan River	Farah River	Ghazni River	Helmand River	Khash Rud River	Tarnak River
Conductivity:				2/9/55			
$EC \times 10^6$ @ 25° C	440	1107	845	1930	320	729	1715
% Na	24	49	33	62	20		63
pH	8.0	8.5	7.7	7.8	8.1	8.1	7.4
Dissolved Solids:							
ppm Salt 1/	321	960	709	1300	258	524	1100
Tons/A. F. 2/	.42	1.31	.96	1.77	.35	.71	1.50
S.A.R:	.80	3.75	5.25	6.25	.75	2.00	6.2
Irrigation Classif:	C2-S1 4/	C3-S1	C3-S1	C3-S2	C2-S1	C2-S1	C3-S2
Cations me/1:							
Ca	2.06	1.02	3.38	2.50	1.46	2.14	
Mg	1.20	6.43	3.48	4.54	1.26	2.23	6.44
Na	1.03	7.19	3.37	12.20	.70	3.00	11.10
K	.06	.16	.10	.36	.14	.07	.18
SUM	4.35	14.80	10.33	19.60	3.56	7.44	17.72
Anions me/1:							
CO_3	.45	1.84	.19	0	.25	.15	
HCO_3	3.30	3.65	5.07	4.95	2.33	4.02	
Cl	.37	3.07	3.29	8.23	.49	2.07	
SO_4 3/	.23	6.24	1.78	6.42	.49	1.20	
SUM	4.35	14.80	10.33	19.60	3.56	7.44	
Number of Samples:	5	1	6	2	3	4	2

1/ Dissolved Solids (ppm) calculated from me/1 x equivalent weight.

2/ Tons/A. F. = ppm salt x .00136.

3/ SO_4 determined by difference, equals difference between cations and anions excluding SO_4.

4/ "S" = Exchangeable Sodium or alkali development hazard: 1 = low, 2 = medium, 3 = high, and 4 = very high or unsatisfactory for irrigation use. "C" = Salinity affecting leaching requirements in irrigation use: 1 = low, 2 = medium, 3 = high and not suitable for soils with restricted drainage, and 4 = very high and unsatisfactory for use except for special crops on highly permeable, freely drained soils.

There is a power potential of 120,000 kw, none of which is developed. The regulatory effect of the completed reservoir when completed and properly operated, can control for irrigation use all but 10-15 % of the annual flow. Additional storage capacity of 500,000-750,000 acre-feet should enable full control of these waters.

The Boghra Diversion Dam and Canal, together with the Marja and Shamalan branches serves about 100,000 acres of land on the upland benches and in the Helmand Valley. The Arghandab Diversion Dam and the South Canal and Tarnak branch canal now under construction will serve another 120,000 acres in the upper Arghandab and Tarnak Areas. The Darweshan Diversion and Canal will furnish controlled water to another 45,000 acres. Thus major storage works capable of regulating use of over 4,500,000 acre-feet of water and major diversion and canal structures to irrigate about 265,000 acres of lands have been or are being installed.

Development of these lands to a state where good crop returns can be assured will take many more years and will require careful planning and financing, as well as sound technical and administrative control during the construction, development and initial farming phases. There has been an estimated 2-4 million dollar increase in increased annual benefits thus far. This is only a small fraction of what these lands can yield if fully developed and properly farmed.

* * * * * * * * * * * *

There has been considerable difference of opinion over the adequacy of water supplies for Tarnak-Arghandab development. Much of this has resulted because 1955, the year this project development was brought forward for discussion, turned out to be the driest on record. It has been assumed by some that the water released at Arghandab that year should be the basis for water allocation determinations. <u>This would presume no future improvement of the present, crude, inadequate irrigation systems or of the present grossly wasteful irrigation practices</u>.

It has been shown in the above presentation of water resources that 7 years out of 10 of water flow records and 14 out of 19 of rainfall records, about 1,225,000 acre-feet or more than double the dry-year inflow may be expected. It has also been shown that about 500,000 acre-feet of water from other streams annually move into and out of the Tarnak-Arghandab area. Thus over 1,500,000 acre-feet is available 70-75% of the time for development and use on the lands in question. There is no argument about water shortage in the dry years.

A comparison of these various opinions and proposals is reduced to basic principles in <u>Table 35</u>. In this study the assumption is made that 20% of the wasted or unused water would be percolation losses. The soils in general are deep to very deep loams to silty clay loams of high waterholding capacity and slow to moderate basic infiltration rates. Water operation trials based on Arghandab inflow characteristics and diversion capacities now available or contemplated in the entire development show that over 90 % of the water on the average can be diverted onto the land. After deducting normally expected reservoir evaporation losses the distribution of use of the available water is shown in <u>Table 35</u>.

It must be pointed out that the value of 1.89 acre-feet for net consumptive use, less effective rainfall, has not been seriously questioned. The differences have been on water quantities, use efficiencies and ways of computing allocations. This value and total quantities of water flowing into the area are taken as basic data for the conclusions reached in <u>Table 35</u>.

Table 35

OVERALL ARGHANDAB-TARNAK WATER RESOURCES AND WATER USE AS REPRESENTED BY DIFFERENT ANALYSES *

8/17/57

Basis of Est.	Estimated that Water is available for the following situations	Net irrigable acres (est. from Surveys)	Overall Efficiency %	Wastage of Water by Various Schemes in Acre-feet per Acre: Total less evaporation	By percolation @ 20%	By Runoff	Gross Wastage in acre-feet of runoff and further evaporation
1/	N. & C. Arghandab presently irrigable	116,728	15.8	10.10	2.02	8.08	943,000
2/	Same but only with Arghandab water	"	19.1	7.99	1.60	6.39	745,900
1/	N. ≠ C. ≠ Lower Arghandab	122,642	16.6	9.52	1.90	7.60	932,000
2/	All presently Irr. N.≠C. ≠ Tarnak & Lower Arghandab	177,583	29.1	4.60	0.92	3.68	653,500
1/	Max. Acreage	193,000	26.0	5.36	1.07	4.29	828,000
2/	N. Arghandab ≠ C. ≠ Tarnak, by Arghandab Water	185,000	30.3	4.34	0.87	3.47	642,000

* Basic Data: (a) 1,229,883 acre-feet inflow in 7 years out of 10 with maximum usable diversion of 1,153,380 acrefeet (Table XXIIIc, June 2, 1957, revision of Water Allocations Report). (b) Net mean per acre evapotranspiration less usable rainfall = 1.89 acre-feet (Table XV, above report). (c) Avg. flow measured at Charharburjak, contributed by other streams (Table 24 of this report).

1/ Use of total inflow of 1,500,000 acre-feet less 100,000 for evaporation losses and spill.

2/ Use of present facilities and of Arghandab inflow less evaporation less spill.

ological Service reports 30 years of records at Kabul but Kabul lies in a high mountain valley, 1,793 meters, and again has only general value. At Kandahar which is at the upper and eastern part of the project areas there are 18 years of records available through the Pakistan Consulate, the local Afghan Meteorological Service, and MKA since 1950. Other locations have from 2-5 years of records.

An exhaustive study has been made of the data available in order to bring as much light to bear as possible on water requirements of crops, rainfall-water yield relations, effective rainfall for crop production. Since this will be a subject of continuing interest and study the summary tables for the 10 weather stations studied are included in the appendices to this report.

Several tables and charts representing analyses of the data and the conclusions drawn from them follow.

a. Temperature -

Mean monthly and mean annual temperatures are plotted for all years of records for the 10 stations in Table 2. Because some records are short and techniques not uniform it is difficult to evaluate reliability and give proper weight to each set of data. In general the hotter areas are in the lower deserts farther away from the mountains and the cooler projects in the higher mountain valleys. This would appear the normal situation. The very short record at Farah and the records for Kajakai and Arghandab, located in narrow valleys, fall out of line with the general trend.

The mean July temperature, the month of highest water use and, therefore, critical for design purposes follows the same general trend with similar discrepancies in order of arrangement. For this purpose the July temperature at Kali Xang was interpolated as the few July records were very much in disagreement.

The average of all projects by months and years gives a fair picture of the general area. The mean annual temperature of 64.8° F and mean July temperature of 87.1° F compares with continental desert climates in similar latitudes and situations.

The Blaney-Criddle formula for irrigation requirements was used to compute the average consumptive use of an expected combination of crops. The mean annual consumptive use factor of 66.46" compares well with Bakersfield, Red Bluff and San Fernando, California; Carlsbad, New Mexico, and W. Central Arizona stations at similar altitudes.

Consumptive use of an assumed average combination of crops with an average per acre use coefficient of 0.65 is 43.2". Since not all land will be in crops every month of the year the actual usage will be somewhat lower. The mean July consumptive use of 5.51" would be a rough indicator of peak delivery requirements. Assuming 75% delivery efficiency, 55% mean irrigation efficiency and 5 % use of return flow, the peak monthly diversion requirement would be approximately 1 acre-foot per acre in crops. This would change with the combination of crops being grown in any one area, their stages of growth and consumptive use at the particular time.

If only the presently irrigable lands of N. & C. Arghandab are developed 8.00 acre-feet per acre of water based on the Arghandab outflow and 10.0 acre-feet/acre based on total stream flow into the projects will be wasted as percolation or runoff. If all lands now usable for irrigation in the N. & Central Arghandab, lower Arghandab and Tarnak (total surveyed areas) were irrigated, 4.6 acre-feet/acre would still be wasted considering only Arghandab water and 5.96, considering all apparently available surface waters. If the maximum acreage potentially suitable for irrigation were reclaimed and developed to its fullest practical use (150% double-cropping) as outlined in the water allocations study 5.36 acre-feet per acre would still be wasted. These various schemes show net overall use efficiencies of 16-29% disregarding reservoir evaporation losses.

The water allocation study which has been the basis for irrigation design in the Tarnak-Arghandab development takes the stand that 185,000 acres can be fully irrigated from Arghandab water 7 years out of 10 or 14 out of 19 according to the records. The net overall efficiency, disregarding reservoir evaporation is 30.3%. It was pointed out in the allocation study that the allocations were predicated on every effort being made by the government and the people to achieve sound water use regulations; to improve and modernize existing irrigation distribution systems and, to carry out education and demonstration and on-farm-training to encourage efficient use of water as well as improved agricultural methods. Even so it can be seen that 640,000 acre-feet or about one-half of all the Arghandab water would still likely be wasted runoff and further percolation into low-lying areas, waste drains and stream channels. It was pointed out in the water allocation study that several streams, parallel to and through the entire length of the Arghandab-Tarnak land areas, offer opportunities for picking up and reusing this waste flow. For the entire system, to the proposed Seraj branch canal, over 500,000 acre-feet could be available for diversion and reuse. If reused at the same efficiency of 30.3% the net return flow usage could be 40% or be equivalent to another 75,000 acres of land.

It appears futile, therefore to continue discussing the water shortages. Certainly about 1 year out of 4 there will be a shortage unless additional reservoir storage is developed. However 75% of the years can produce their full amount and the land will produce 75-95% even in the dry years. Assuming 50% yield in dry years the income ratio in favor of the larger acreage is 1.35:1. The government must decide whether it wants to aggravate past wasteful methods and further waterlog and salinize the Central and N. Arghandab Areas, 41,000 acres of which is already too saline-alkali to grow crops, or spread the water more evenly over larger acreage and thus reduce the dangers of waterlogging as well as encourage more efficient use and, in the long run, reap greater economic returns.

To satisfy those who are further concerned with soundness of these water allocation studies, a comparison is made in Table 35-a, between allowances made for water losses and wastage in computing the Arghandab-Tarnak requirements and the range of losses and wastes reported by Houk as commonly experienced in irrigation projects of the states.

By comparison it can be seen that the allowances for wastage are generally above the middle of the ranges quoted by Houk and the proposed efficiencies of use well within the ranges he quoted. The use of 5% return flow is far below the minimum quoted by Houk and in view of the fact that 95% as much water is passing the Kala Bist station as waste flow as leaves the Arghandab Reservoir, return flow could easily be a much higher figure.

It has been repeatedly stated that even these allowances are predicated on making substantial improvements over a period of years in the Afghan irrigation and drainage systems, water management, and irrigation practices. Every effort has been made to keep these studies on a sound engineering and agronomic basis.

Table 35-a LOSSES AND WASTE OF IRRIGATION WATER 8/22/57

	COMMON EXPERIENCE REPORTED 1/	ESTIMATES USED FOR ARGHANDAB-TARNAK AREA 3/
During Delivery		**During Delivery**
Average field evaporation before topsoil dries	0.5 inch per irrigation	0.5" in. per irr. in hot season
Surface waste, allowance for large projects	10 per cent of diversions	26.4 % (used as part of farm irr. loss)
Seasonal percolation losses, except on porous soils	0-1.5 acre-feet per acre	0.87 acre-feet @ 14% of gross
Losses of flow in farm ditches	5-50 per cent per mile	(heavy to med. soils) 10% (4% of gross)
Deliveries to farms (see Chapter 11)	1-7 acre-feet per acre	2.71 (.263); 4.17 (avg.); 4.99 (.737)
Cons. use, diversified crops (see Chapter 10)	1-3.5 acre-feet per acre	2.25 A.F./Acre
Irrigation efficiencies, common farm crops	20-50 per cent	35-50% on diff. soil types
Irrigation efficiencies, fruit and special crops	35-70 per cent	45-65% on diff. soil types
Avg. irrigation efficiencies on large projects	30-50 per cent	35-65% all soils, mean above = 37.95%
During Conveyance		**During Conveyance**
Evaporation from canal surfaces	Negligible	Negligible
Evapo-transpiration at canal banks	Negligible	Negligible
Canal seepage, large projects, mostly unlined canals	15-45 per cent of diversions	Main canal lined
Seepage losses, most canals lined	5-15 per cent of diversions	Used 15%
Waste on large projects, ample water supplies	5-30 per cent of diversions	Restricted supplies 26.3% of years
Waste on large projects, limited water supplies	1-10 per cent of diversions	Used 5-8%
Over-all efficiencies, large projects	20-35 per cent	43% (.263); 34.5% (avg.); 28.8% (.737)
Diversions for large projects (see Chapter 11)	2-10 acre-feet per acre	3.25% (.263); 5.21% (avg.); 6.23 % (.737)
2/ Return flow for large projects	1-3 acre-feet/acre, 50-65% reusable, 15-50% gross diver.	5% of gross diversion reusable
1/From Irrigation Engineering, Volume I, Chapter 12, Page 392, by Ivan E. Houk, Consulting Engineer Denver, Colorado 2/ibid pages 412-418		3/From Arghandab-Tarnak Water Allocations Study, MKA., 1956

3/NOTE: The estimates are based on complete development, rehabilitation of old systems, sound water management and education and demonstration of improved irrigation techniques among the farmers. Present overall efficiency calculated at 16%.

IV SOIL RESOURCES:

1. Soil Survey Report and Maps.

a. How a soil survey is made. Soils survey and land classification requires the use of specialists trained in this field of work and with years of experience under competent supervision. Soils may be highly variable in character and change remarkably in short distances or by contrast may be quite uniform over considerable area and for several feet downward. The influences of climate, topography and vegetation acting over a period of time on a given geologic-source material will produce recognizable soil characteristics which more or less consistently repeat themselves and so can be classified. Within these broad influences, however, wide local variations occur which affect plant adaptation and growth, and soil management requirements. Since production of crops is the primary objective of irrigation development, the survey techniques, soils delineations and classes of land used in the Afghanistan surveys are necessarily utilitarian in objective. The standards employed and legends used are adapted from procedures and standards of soils survey and land classification of the U. S. Department of Agriculture, Soil Conservation Service and the U. S. Department of Interior, Bureau of Reclamation. Certain modifications are made locally as needed and are explained in the Survey Manual for Helmand Valley Surveys.

Briefly, the trained soil surveyor systematically traverses and examines a parcel of land at regular intervals depending on the detail of investigation required. Aerial photos of 1:8000 scale are used for detailed work and 1:20,000 for the more rapid detail-reconnaissance type of investigations. Open pits at 100-200 meter intervals are dug to depths of 1.5-2.0 meters for detail studies. Augers and spades are used to get closer detail. The soil horizons exposed by the pits are systematically logged with respect to thickness, texture, consistence, structure and permeability of each significant layer. Notations of special features such as presence of gravel, lime, salts, alkali, gypsum, and watertables are noted. Any tendency toward compaction and cementation is recorded. The growth and character of plants and plant roots is studied as a key to the soils ability to grow crops. Surface features, slope, erosion, present land use and types and appearance of vegetation all are considered as clues to those characteristics of the land which will affect irrigation agriculture. Samples of soil horizons are sent to the laboratory for analyses and these results are used in conjunction with the field observations to establish a final decision as to the soils proper symbol characterization on the map.

Soils and drainability surveys are made concurrently in Afghanistan so that any factors affecting the irrigation capability of the land can be determined. The detail of this phase of the surveys is explained under Section V. When the character of the soil and its associated site factors of slope, erosion, wetness, salinity and drainability are known, its potential and present land capability classes are assigned.

b. How to use the soils and drainability survey maps and reports. The soils and drainability survey maps and reports are a compilation of detailed observations, measurements and analyses of land and subsurface features and vegetation, interpreted by skilled technicians for use in evaluating the potential use and productivity of a parcel of land and the problems inherent with its development.

The maps are compiled into original and documented survey and investigational data, and, later, interpretative maps are compiled from these data in light of the known climate and agriculture of the area and experience on similar soils and land conditions.

(1) Basic Data (Shown by symbols described in detail in the Survey Manual).

(a) The Soil Survey shows:

A. Base map features.

1. Roads, Villages, Ruins.
2. Drainage.
   (a) Streams classified as to perennial or intermittent character.
   (b) Washes.
   (c) Gullies.
3. Irrigation and drainage structures (if constructed at time of survey).
4. Natural land features.
   (a) Mountains, hills and rock outcrops.
   (b) Dunes and sand drifts.
   (c) Marshes, swamps, lakes.
   (d) Other significant features.

B. Features shown by Survey Symbols.

1. Soils: Depth, texture of surface soil, subsoil and substratum permeability, and water holding capacity (interpretative symbols based on texture, structure, consistence, porosity and on organic matter, gypsum and lime content of each significant horizon).

2. Associated or site factors: Salinity, alkalinity, presence of gravels and stones, presence and depth to groundwater.

3. Topography: Degree of slope, and degree of regularity or unevenness of slope (actual land elevation contours shown only on topographic survey base).

4. Erosion and Erodibility: Degree and kinds of wind and water erosion evident at time of survey - also tendency to erode is interpreted from the composite symbol.

5. Underlying or Parent Soil Materials: The type of underlying materials within a 5 or 6-foot depth are noted as they affect soil character, drainability and plant growth. These are generally classified as to origin, i.e., recent or old water-transported materials, bedrock, wind-transported materials, etc. The dominant character is shown by the symbols, i.e., L = limestone, Z = gravel, etc.

6. Present Land Use: The use of the land for field crops, orchards or vineyards is noted. If in natural vegetation the general type is shown. Some lands are barren (fallow) or abandoned. All these give clues to present soil conditions and are useful in planning future work.

C. Special Location Symbols.

1. Triangulation points and bench marks.

2. Deep pits for soils and drainage studies and sampling of soils.

3. Location and identification of samples analyzed in the laboratory.

4. Location of field tests such as infiltration tests and leaching trials.

(b) The Drainability Survey:

The drainability survey is concerned primarily with those subsurface features which determine the relative ease or difficulty of removing waters lost by percolation and of maintaining groundwater tables at depths which will permit agricultural use of the land. In the form of pit logs, maps, graphs, charts and tables the basic field data includes:

A. Logs of Substratum Materials.

A systematic logging of materials to depths of several meters to determine the depth, thickness and permeability of aquifers, the depth to and character of barriers to downward movement of water, the presence or absence of watertables and the hydraulic conductivity of saturated zones.

B. Ground Water Measurements.

By means of pits, open wells, perforated pipe, the watertable levels are observed periodically to determine fluctuations with seasonal conditions of irrigation, rainfall and dry periods. Piezometers are used where necessary.

C. Elevation and Topography Measurements.

The elevations of each pit, well or pipe and their bench marks and measuring points are accurately determined and tied into the area topographic base maps.

D. Field Tests and Laboratory Analyses Include:

1. Measurement of hydraulic conductivity of saturated zones.

2. Chemical analyses of groundwater.

3. Mechanical & permeability analyses of various substratum horizons.

4. Rate of flow measurements of existing drains.

E. All of the above data is compiled for presentation in the form of charts and maps and tables showing:

1. Depth to and slope of very slowly permeable or impervious layers.

2. Thickness, depth to and hydraulic conductivity of possible aquifers.

3. Depth to and slope of existing watertables.

4. Fluctuations of watertables with seasonal irrigation and rainfall.

5. Quality of groundwater.

6. Flow of groundwater in existing drains.

(2) Interpretation of Data:

Interpretative Maps (Generally in colors or hachures) show the broad groupings or classifications made for specific use purposes from careful weighing of all facts assembled by the survey. The following are available or can be made from the soils and drainability surveys.

A. From the Soils Survey Maps (after correlation with drainability maps).

1. General or project selection and layout.

a. Land capability classes (maps & tables).

(1) Present.
(2) Potential.

b. Project map showing boundary and lands which are
(1) Presently irrigable,
(2) Irrigable when reclaimed,
(3) Not recommended for development.

2. Land Development Problem Areas.

a. Land clearing map showing
   (1) Crop land
   (2) Brush and grass land
   (3) Barren (abandoned) land

b. Land leveling map showing relative degrees of leveling required

c. Map of wet lands needing drainage now, showing relative degrees of wetness

d. Map of lands needing leaching of salts, showing relative concentrations of salt

e. Map of lands needing alkali treatment

f. Map of lands needing deep plowing of sands or other sand control works

3. Irrigation Design and Layout.

a. Water requirements map showing TRAM capacities and acres per cfs data for sublateral design.

b. Table of farm irrigation layout requirements by soil types, i.e., lengths and widths of borders and irrigation head for different TRAM and infiltration conditions.

4. Farm Layout and Water Allocations.

a. Land capability classes (above)

b. Crop adaptations maps, charts and tables

c. Tables of monthly irrigation requirements for crops fitting each major land class and soil group and probable water allocations by land areas and types of farms.

B. From the Drainability Maps and Charts and Topographic Data:

1. General project layout of project main and collector drains.

2. Sub-collector drains and farm drains (type, depths, spacings, direction and slope of drains is worked out later in detail for each local condition as the need for and construction of drains progresses).

3. Slow or difficult areas which may need special attention or may justify being deferred or omitted from project development because of costs and probable low agricultural returns.

4. Data for predicting the level of drainage it is practical to achieve in any given area (may determine selection of crops for the soils of the area).

LAND CLASSIFICATION

Agricultural classification of land is designed to reflect its suitability for irrigation for growth of crops and its productivity potentials and general land values. While several schemes of classification are in use by different agencies, none of these appeared to quite fit the needs for development of lands in Afghanistan. The following scheme of classification embodies the principles used in the several land classifications now in vogue, but special adaptations have been made to fit conditions which prevail in Afghanistan with respect to physical conditions of land and climate.

The principle followed is that permanent, non-removable (from a practical standpoint) or recurrent characteristics of the soil and its associated factors are classified as the degree to which they limit the use capability of the land. Temporary or removable limitations such as loose rock brush, or tree growth, uneven surface conditions requiring levelling, are considered as temporary limitations affecting the cost of development only. These are not permanent land features affecting land use capability unless so extreme that land development is impractical. However, it is expected that costs of development will be considered for all classes of land and their present conditions in relation to the economic and social need for developing the land and the expected benefits to be derived.

CLASS I (Green color on soils maps): Land which is suitable for irrigation of all climatically adapted crops with no restrictions in use other than good irrigation farming practices. Such practices include the use of good rotations with soil-building crops. The use of moderate amounts of manures and commercial fertilizers may be required for high yields but fair to good yields can be maintained for a long period of time with minimum fertility management. Routine smoothing and floating for seed bed preparation and irrigation is a regular practice. Surface drainage coupled with efficient use of water should normally maintain the soil in a well-drained condition. Surface soils should be easily tilled with no special treatment necessary to control crusting, salts or alkali. Class I soils are deep and roots, air and water penetrate well; yet the water holding capacity is good. Topographic conditions are commonly such that land development is relatively easy.

CLASS II (Yellow color on soils maps): Land which is suitable for irrigation of a majority of the climatically adapted crops but has one or more permanent limitations which require practices in addition to good irrigation farming methods to maintain productivity. Generally Class II lands will be less productive, be adapted to a narrower range of crops, be more expensive to develop, or be more costly to farm than Class I lands. Special practices which may be required include: (1) Wind

or water erosion control, (2) Special irrigation development such as bench levelling, and irrigation methods such as contour irrigation and restricted use, (3) Special tillage operations to correct surface crusting on hard pan layers, (4) Correction of low fertility by special application of fertilizers or soil amendments, and (5) improvement of surface and subsoil drainage and removal and control of salts. Such improvements when accomplished should result in higher sustained yields.

CLASS III (Red color on soils maps): Land which is suitable for irrigation of a limited number of climatically adapted crops and generally requires special treatments and continuous practices to overcome major deficiencies and maintain yields. Generally, these are lands of restricted suitability requiring careful management for fair to good yields of adapted crops. Major drainage measures such as deep open ditches and open or tile drains may be needed. Recurring reclamation practices to control salinity and alkalinity may be required. Other measures may include special and extensive levelling such as bench terracing and contour irrigation of steep slopes. Some soils of this class have such lower water holding capacity and high permeability that irrigation must be frequent and with high heads and short runs. Soils with low fertility requiring continuous use of large quantities of fertilizers will be placed in this class. Class III includes some lands subject to periodic damaging overflows but otherwise productive.

CLASS IV (Blue color on soils maps): Land which is not suitable for continuous irrigation of common irrigated crops but may have limited use for some of these crops. If properly developed, it can be irrigated safely and with fair to good yields when in vegetation such as trees for woodland products or grasses and legumes for hay or pasture. Such lands may be too shallow, too steep, too frequently overflowed or remain too wet, saline or alkaline for practical or economic use as regular cropland. Under special situations, such as abundant available water supplies, irrigation to produce trees for fuel or forage for livestock may be justified, or special crops adapted to the extreme limitations of the land.

CLASS V (Brown color on soils maps): Land which is unsuited for irrigation of any crops. Such lands include steep or broken areas, mountains, river wash, stream beds, extremely rocky or gravelly soils, sand dunes, marshes, and salt or alkali flats not practical to reclaim. Unusual and special uses of water may have value on some of these lands, however, such as the flooding of marshes to maintain food for wild life.

3. CHARACTERISTICS OF SOUTHWEST AFGHANISTAN SOILS WHICH AFFECT DEVELOPMENT, USE AND MANAGEMENT OF LAND RESOURCES.

A large proportion of the potentially irrigable lands have been examined. General or exploratory reconnaissance soils surveys have covered well over 2.5 million acres in search of possible lands for development. Reconnaissance soil and drainage surveys have covered 678,135 acres, semi-detailed surveys have covered 464,335 and detailed surveys 577,786 acres as measured from maps on file.

It is impossible to give more than a very general picture here of the soils and land conditions found in these surveys and studies. Supplemental reports covering each project area in more detail have been prepared and are available to those who wish to study these areas in detail. A general summary of soil conditions is presented here.

a. General origin and development of soils. The soils of most of the potentially arable lands are developing from alluvial and aeolian materials. The original bedrock sources are the uplifts of the HinduKush and its westward ranges the Koh-i-Baba and

TABLE 9

S. W. AFGHANISTAN CLIMATE
MONTHLY AND MEAN ANNUAL TEMPERATURE BY STATIONS
TOGETHER WITH COMPUTED AVERAGE EVAPO-TRANSPIRATION
(Stations in order of elevation)

June 22, 19[illegible]

MONTH	CHAKANSUR	MARJA	CHAH-I-ANJIRS	FARAH	HERAT	KANDAHAR	KAJAKAI	ARCHANDAB	KABUL	GHAZNI	TOTALS	t = AVG. MO. TEMP.	p = % SUNSHINE HOURS 1/	CONS. USE FACTOR = tp/100	MO. EVAPO-TRANSPIRATION = .65 x f 2/
JAN.	43.7	46.1	45.8	52.3	40.4	44.0	45.8	44.3	32.0	21.6	416.0	41.6	7.22	3.00	1.[illegible]5
FEB	50.9	52.9	52.1	57.8	44.8	48.7	52.4	51.6	31.[illegible]	22.6	464.8	46.5	6.99	3.25	2.[illegible]1
MAR.	58.3	63.0	60.9	67.7	58.[illegible]	57.3	60.2	61.0	43.5	33.9	558.2	55.8	8.37	4.67	[illegible]6
APR.	72.1	69.1	75.0	72.2	62.7	67.1	69.9	72.1	54.0	45.8	660.0	66.0	8.74	5.77	3.[illegible]5
MAY	83.2	81.9	83.9	82.1	71.7	75.9	80.2	78.8	65.3	58.1	761.1	76.1	9.60	7.31	4.[illegible]5
JUN.	88.6	87.8	89.2	86.8	79.0	81.1	86.6	87.9	73.8	64.6	825.6	82.6	9.57	7.90	5.[illegible]4
JUL.	(93.0)	90.9	92.2	93.7	84.8	84.7	90.2	91.1	78.3	72.4	871.3	87.1	9.74	8.48	5.[illegible]1
AUG.	87.6	85.6	85.4	87.3	82.5	81.6	78.9	87.2	74.8	79.2	830.1	83.0	9.27	7.69	[illegible]00
SEP.	77.8	78.7	77.9	77.8	73.2	72.9	75.8	80.1	66.9	63.4	744.5	74.4	8.34	6.20	4.[illegible]3
OCT.	66.7	64.7	66.4	68.0	62.7	63.6	63.9	66.2	55.2	51.9	629.3	62.9	7.95	5.00	3.[illegible]5
NOV.	58.9	57.2	55.2	66.3	51.1	53.5	56.2	57.5	45.0	41.2	542.1	54.2	7.13	3.86	2.[illegible]1
DEC.	49.9	49.4	48.8	59.0	41.6	45.6	50.1	49.7	34.7	42.2	471.0	47.1	7.08	3.33	2.[illegible]6
TOTALS	830.9	827.3	832.8	871.6	746.6	716.0	810.0	827.5	654.7	596.9	7774.0	777.4	—	—	—
AVG.	69.2	68.9	69.4	72.4	62.2	64.6	67.5	68.9	54.6	49.7	—	64.8	—	—	—

1/ Percentage sunshine hours at Latitude 31° 30' North.

2/ Mean use coefficient based on following crop percentages: Grain - 17%, Cotton - 8, Orchard - 10, Vineyard - 10, Truck - 6, Misc.Crops - 20, Perennial Legume-Grass Meadows - 20, Others - 7%.

Note: Actual project use would be lower since not all land would be in crops continuously.

Parapamisus. These are rugged, generally barren rocks rising to 25,000 feet in the extreme northeast and dropping gradually to 8000-12,000 feet in the western part of the country near Herat. Extreme tilting, folding and warping in them is evidence of the pressures exerted during the uplift. Glacial and post-glacial movement of materials from these uplifts cover upwards of 60,000 square miles to the south and southwest of the mountains and foothills.

(1) Desert Plains Soils - The Dasht-i-Margo lying north of the great loop of the Helmand (see Map LD-17 R 4) consists for the most part of very thin reddish desert soils over outwash gravels highly impregnated with lime. Gypsum beds occur only a few inches below the surface in many places. A few areas in this vast, relatively barren desert, have accumulated a sufficiently thick mantle of soil to afford some promise of agricultural use. The deeper desert soils have in many places a very compact, reddish brown, sandy clay loam lower subsoil which is slowly permeable. Over-irrigation of the more permeable upper horizons has resulted in perched water tables and salinizing of these lands by capillary movement of saline waters to the surface. Compaction and cementation in all degrees is found in these desert soils. Cementing agencies appear to be calcium carbonate, silicates and in a few places iron oxides. Cemented layers vary widely in thickness, texture and density. Caliches, lime-cemented sandstones, shales and a layer of conglomerate, (silica and lime cemented outwash gravel and cobble), is common at depths of 1-5 meters under the surface. This material is so dense it resembles concrete and when removed often breaks across the natural rock rather than through the cementing matrix. These relatively impervious rocks pose a serious drainage problem for most desert soils so far examined. Only where these rocks lie sufficiently deep and more open gravels and sands occur above them have drainage of the irrigated lands on the desert plains been reasonably adequate.

Considerable agricultural use is being made of these soils with varying degrees of success. The Marja project 27,000 acres, Nad-i-Ali or Boghra Project 18,500 acres and parts of the Seraj project 60,000 acres, North Arghandab 25,000 acres, and Tarnak project 28,000 acres are red desert soils on outwash plains materials and underlain at varying depths by cemented or compacted layers, hardpans, or conglomerate. The Bakwa area lying between the Khash and Farah Rivers at the base of the Koh-i-Baba range is underlaid by conglomerate throughout a large part of the area surveyed. In general here, however, the soils are thicker and more continuously deeper than in the deserts projects mentioned above.

Textures, depth and permeability vary widely. The highest proportion are thin soils with grayish brown or weak reddish brown silt loam, loam or fine sand loam surface soils over thin to moderately thick reddish brown loam to sandy clay loam subsoils containing varying amounts of gravel. Lime in soft concretions is common. Some soils have thick layers of calcium carbonate of varying degrees of hardness. Often slight rises or knolls in an otherwise smoothly sloping landscape will consist of thin, gravelly and, commonly, highly saline soils over beds of crystalline gypsum interspersed with gravels and sands. The 'gotch' pockets are very rapidly permeable and have little capacity to hold water. Consequently, irrigation and ditch waters are quickly lost by percolation. Salts are common in the gravelly desert soils, the concentrations varying from 0.5% - 3.0% in the surface foot of area/examined. These are chiefly chlorides, sulphates, and bicarbonates. Very few desert soils appear to be strongly alkaline. Soluble carbonates are low.

In the surveys selection of potentially arable lands has been difficult because of the substratum drainability. Soils selected for adequate depth, moisture retention,

permeability and freedom from excessive salts or alkali may often be underlaid at 1½ - 3 meters with very slowly permeable compacted clay and gravels or layers of caliche or conglomerate rock. It has been necessary concurrently with and following the soils surveys to make intensive subsurface explorations by means of open pits hand dug to rock or to depths of 3-4 meters. Soils having slowly drainable substratum conditions are likely to be difficult and costly to develop. Maintenance of sufficient downward movement of water through the soil and into outlet drains to counteract capillary rise of saline groundwaters is necessary for successful crop production. Unless such conditions can be met within reasonable costs, classification of such soil areas is made to reflect these problems of development.

Another problem of development less serious as a whole but locally very important in these desert plains is that of wind-erosion. At certain periods of the year strong winds sweep across the deserts, causing considerable movement and sorting of soil particles. Vast dunes are footloose on the barren deserts where they have aggregated from wide areas. The general dune movement varies with the relative shifting of the wind directions. The strongest and most continuous winds sweep down across the Chakansur-Siestan basin in a south-southwest direction. Some influence from the mountain ranges southward in Baluchistan and the winds moving inward from the Persian Gulf cause a major shift in direction so that the sand movement shifts more eastward across the lower Dasht-i-Margo and the Registan, a vast dune-covered desert south of the Helmand, and continues eastward until the 6000-8000 foot ranges in Pakistan force the winds to rise and drop their sands near the Afghan-Pakistan border. The winds seem to move northeasterly here and the finer sediments are dropped in the upper plains and valleys such as the upper Tarnak plain near Mukur. Here silts, apparently of aeolian origin, are many feet in thickness over a large area. Other writers have described this grading and sorting process which is so strongly evident from study of aerial photographs of the lower Helmand, the Chakansur, and the Registan.

The hazards of project development are quite apparent where dunes are in movement on the windward side of irrigation and drainage structures. This is a serious problem in parts of the lower Marja, the central Darweshan, lower Shamalan, Garmsel and Chakansur areas. More detailed studies are needed to determine the rate of movement of sands, and costs of maintaining structures where choking of canals or drains occur. Means of control will be discussed in the chapter on irrigation farming practices.

Soil fertility is another desert soil problem. Many of the sandier types and thin, more gravelly soils are low in available phosphate. Tests repeatedly show this to be true in the Nad-i-Ali area. Organic and nitrogen are typically low in most desert soils but these can be maintained at a fair level by good rotations, use of legumes and animal manures. The supplying of phosphate fertilizers constitutes a definite problem for the future, however. Preliminary mineral surveys have failed to reveal sources within the country. This is one investigation that should be continued as an improved and sustained productivity of these desert soils will require the use of phosphate fertilizers.

(2) The soils of the recent terraces and valley fills.

By far the more promising lands for irrigation development are the deep valley fill and river terrace soils lying between the Arghandab and Dori rivers, along the Arghandab and Helmand valleys and to a lesser extent in the valleys of the Farah and Khash. Extensive areas of silts of mixed loessial and alluvial origin occur in the

upper Tarnak plains near Mukur but are not included as a part of the Helmand Valley Development program.

The Valley fill soils represent the gradual accumulation of alluvial sediment together with wind-laid materials at the lower extremities of long outwash slopes and fans and above the more recent stream terraces. The Arghandab and Tarnak Areas are the largest of these. Two narrow but steep, rugged uplifts run southwesterly along the east side of the present Arghandab and westside of the present Tarnak channels. These uplifts together with the hills and high bluffs of the Registan lying south of the present Dori-Arghandab channels have slowed down waters moving outward from the desert fans and slopes long enough to have built up large areas of thick silts, fine sands, and clays. These soils become thinner toward the upper slopes until they become indistinguishable from the true reddish desert outwash plains soils. In the upper reaches the compact reddish brown subsoils of the desert plains soils extend underneath these later, less weathered deposits. Irrigation with silt-laden waters during high runoff has through the centuries built thick layers of silts and fine sands over the original soils. Stratification of thin soil layers is common in these older irrigated sections.

In general the valley fill soils are deep, moderately light brown to very pale brown silt loams and fine sandy loams with silt loam to silty clay loam subsoils. Soil structure varies depending on the manner in which the soils were laid down and developed. Where stratified with thin lenses of compact, massive, silty clays, the permeability is low. The more uniform profiles, particularly those with weakly prismatic to nuciform structure are more permeable and better drained. Underlying materials vary from the red desert soils and outwash gravels to more recent alluvial gravels and sands. In some areas, as in the low flats extending southwest from Kandahar, deposits of silty clays and silts extend to over 4 meters in places. Drainability varies widely from place to place. A part of the lower benches of the N. Arghandab project, the long, low flats through the Central Arghandab and a part of the central and lower silt plains of the Tarnak and Central Arghandab, adjacent to the Tarnak river, have such thick silt deposits that drainage will be a serious problem if excess waters are wasted in and above these areas. In addition to the Tarnak-Arghandab area, these deep valley fill soils occur near Khushk-i-Nakhud, in small areas along the west side of the Helmand between Musa Kala and Kajakai, and along the upper Farah. There are no doubt other places not yet surveyed or observed.

The more recent series of terraces and benches along the various rivers constitute important agricultural areas. Dominantly the soils are deep, light-colored silt loams, loams and very fine sandy loams. Along the Helmand considerable areas of uniformly sandy soils, sandy loams to loamy fine sands, also occur. Some of the older terraces have accumulated, through past use of silt-laden waters, several feet of silts, fine sands and clays. Old pottery shards occur extensively under the Shamalan terrace soils at about one meter depth. Part of this deposition is probably due to a period of heavy flood deposition, since the shards do not continue upward through the profile. Some parts of the terrace benches along the Arghandab and Helmand are heavy silty clay loams and silty clays several feet in thickness. These do not drain well and in many cases are now barren and highly saline-alkali. Generally, however, the stream terraces are moderately to well drained at present and appear to be well-adapted to irrigation development.

(3) Recent alluvium along the several streams is so subject to inundation, scouring and deposition during flood periods that very little has remained long in cultivation. Some few areas are farmed along all the rivers, but the agriculture is hazardous, unpredictable and generally of little permanent value. With the installation of reservoirs, diversions, and new canals, and with extensive control works, some of these lands may be brought into use. For the most part they are loamy fine sands to loams, uniform to stratified profiles. The surface is very irregular, numerous old stream channels meander throughout the areas, wind erosion has left much of the land in badly hummocked condition. Scouring and redeposition has resulted in frequent gravel and sand bars. These areas for the most part are covered with jarru grass and salt cedar. Some bermuda occurs in smooth sites; marshy areas support cattails, rushes, plume grass and giant reed veldt grass, and some willows. The land has water tables varying from a few inches to 3-4 meters below the surface. Salinity is generally high.

In the lower Darweshan, the Garmsel and Chakansur areas, barren shifting sand dunes are moving across these lands onto the stream terraces or upon to the generally high desert plains. In these areas reclamation of recent alluvial soils would be a most discouraging task. In the upper Helmand and Arghandab drainage and levelling can be fairly successful on the loamy fine sands to sandy loams. The danger of flood damage to structures is ever-present, however.

b. Principal Physical Properties of S. W. Afghanistan Soils

(1) Permeability

Since permeability affects irrigation design, farm irrigation efficiency, percolation losses and drainage, it has been mapped in the field survey and determined by lab and field measurements.

Table 36 summarizes the field infiltration tests made during the surveys. They were made with double rings, 22" outer and 15" inner, set several inches into the soils. Water was maintained at about the same level in the two rings and the rates determined on the basis of the inner ring. The wetted soil pattern was determined by excavating after allowing 2-3 days for the moisture to nearly reach equilibrium. Infiltration rates were measured also during leaching trials of basins and in irrigation efficiency measurements. Initial intake rates ranged from as low as 0.5 inches per hour on a strongly saline-alkali silty clay to as high as 4.07 inches per hour on a coarse sandy loam. Final infiltration rates after soils had been saturated for 10-100 hours ran from as low as 0.02 inches per hour on a highly saline alkali silty clay to as high as 1.5 inches per hour on a sandy loam. No loamy sands or sands were included in these trials, but a loose very gravelly soil ran 20 inches per hour. The duration of the tests varied from 10-200 hours depending on the soil.

Table 37 summarizes the rates by soil textures and subdivides these into surface and subsoils. The effect of high exchangeable sodium with or without gypsum was studied as a clue to reclaimability. The soils with high exchangeable sodium and low gypsum content had significantly lower final intake rates than normal soils. This is characteristically common in subsoils because of the tendency for the clays to deflocculate and "jell" or seal off the normal soil pores transmitting water. However, only the silty clays dropped below 0.10 inches per hour, which is considered as potentially reclaimable. Those soils containing moderate to high amounts of gypsum remained permeable. The normal basic rates for the general textural groups are sandy

TABLE 36 — INFILTRATION STUDIES SUMMARY — FIELD TRIALS BY PROJECTS — June 27, 1957

Name of Project Area	Location	Soil Symbol	Infiltration Data: Initial Rate in./hr.	Final Rate in./hr.	Hours Test Ran	Average of Texture Represented: Top Soil	Sub-Soil
Tarnak 1956	Shamshier Area	(1M33)	2.25	0.20	45	Si L.	Si.C.L
no/gyp.	Photo 24-3711	1H12-PS5	.50	0.06	40	Si.C.	Si.C.
w/gyp.	" "	"	.70	0.10	44	"	" "
no/gyp.	" "	1M32-PS5	.90	0.25	30	Si.L.	Si.L.or L.
w/gyp.	" "	"	1.15	0.30	30	"	" " "
no/gyp.	" "	1H12-PS5	0.60	0.05	43	Si.C.	Si.C.or C.
w/gyp.	" "	"	0.70	0.04	110	"	" " "
no/gyp.	" "	1M22-PS5	0.90	0.15	45	Si.L.	Si.C.L.
w/gyp.	" "	"	0.60	0.20	37	" "	" " "
no/gyp.	25-3876	1L33-PS5	0.95	0.15	32	L.S.	L.or S.C.L.
w/gyp.	"	"	0.75	0.18	27	"	" " " "
no/gyp.	"	1M23-PS5	0.95	0.19	32	Si.L.	Si.C.L.
"	"	"	0.95	0.12	57	" "	" " "
"	"	1M33-PS5	1.20	0.15	46	" "	Si.L.
w/gyp.	"	"	0.85	0.20	32	" "	" "
no/gyp.	25-3930	1M23-PS5	1.15	0.18	29	" "	Si.Cl.L.
"	"	"	0.90	0.18	50	" "	" " "
"	"	"	0.60	0.08	85	" "	" " "
"	"	"	0.60	0.06	138	" "	" " "
"	26-4001	1M34-PS5	1.50	0.04	80	" "	Si.L.
w/gyp.	"	"	2.00	0.04	80	" "	" "
no/gyp.	"	1H22PS5	2.00	0.05	80	Si.C.or SCL	Si.C.
no/gyp.	26-4002	1H23XPS5	1.5	0.05	120	Si.C.	Si.C.L.
w/gyp.	"	"	1.5	0.06	120	" "	" " "
no/gyp.	26-4003	1H12PS5	2.0	0.05	140	" "	Si.C.
"	26-4004	1M23PS5	2.0	0.10	85	Si.L	Si.C.L.
"	"	1H12PS5	0.75	0.04	140	Si.C.	Si.C.
"	26-4069	1H22PS5	1.90	0.03	145	" "	" "
w/gyp.	"	"	1.50	0.03	200	" "	" "
no/gyp.	26-4125	1M33PS5	1.30	0.05	140	Si. L.	Si.L.
w/gyp.	"	"	1.70	0.06	140	" "	" "
no/gyp.	"	1M23PS5	1.25	0.12	60	" "	Si.C.L.
w/gyp.	"	"	1.50	0.12	60	" "	" " "
no/gyp.	26-4127	1H22PS5	1.50	0.02	250	Si.C.	Si.C.
"	"	1M33PS5	1.70	0.20	100	Si.L.	Si.L.
w/gyp.	23-27	"	2.25	0.35	75	" "	" "

Note: Above tests were run on barren severely saline-alkali land with no land preparation. The amount of active gypsum was not properly computed and the amount added was far below gypsum requirements. All tests were made with double rings replicated 3-4 times.

Name of Project Area	Location	Soil Symbol	Initial Rate in./hr.	Final Rate in./hr.	Hours Test Ran	Top Soil	Sub-Soil
Tarnak 1953	Deh Rajab Plots			Avg.= .16			
	no treatment	1F12PS5	1.25	F =0.15	570	Si.C.L.	Si.C.
	Same ≠ 15% of gyp. req.	"	2.00	0.20	260	" " "	" "
	Same ≠ 46% of gyp. req.	"	2.00	Avg.= .32 F=0.30	305	" " "	" "

The above is from leaching trials in basins plots replicated 4 times in both basins and double rings.

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Name of Project Area	Location	Soil Symbol	Infiltration Data: Initial Rate in./hr.	Final Rate in./hr.	Hours Test Ran	Average of Texture Represented: Top Soil	Sub-Soil
Darweshan 1956							
Fallow	31-79	1M32	0.75	0.15	69	Si.L.	Si.C.L.
Wheat	31-81	1M22	0.35	0.19	70	" "	" " "
Jarru	30-73	1S34	3.35	0.75	46	S.L.	L.
"	30-74	1S44	2.50	1.20	46	S.L.	S.L.
"	30-74	1S45	2.41	1.50	25	S.L.	S.L.
"	30-74	"	1.45	0.8	25	" "	" "
Jarru,Catclaw	31-86	"	1.97	1.15	9	" "	" "
	30-77	1S33	2.50	1.25	30	" "	L.or S.C.L.
Wheat	30-77	1S44	2.46	1.10	45	" "	S.L.
(Fallow)	30-76	1S45	1.60	0.45	69	" "	S.L.or L.S.
Wheat	30-76	1S43	4.07	1.20	45	" "	" " " "
Fallow	30-78	1M33	1.25	0.20	46	Si.L.	Si.L.
Fallow	30-78	1M33	1.04	0.15	46	" "	Si.C.L.
Fallow	31-90	1M32	0.87	0.20	45	" "	" " "
Fallow	31-89	1M22	1.12	0.25	70	" "	" " "
	31-86	1S34	2.70	0.60	45	S.L.	L.or Si.L.
Fallow	30-77	1S43	2.12	0.70	45	" "	S.L.or L.

Note: These tests were made on normal soils relatively free of salts, all tests are double rings replicated 4 times.

Seraj 1956							
*no/gyp.	S15.4-W03.0	3M36SP5S5	—	.60	81	L.	L.to SL.
*w/gyp.	" "	"	—	.90	52	L.	" "

* Above represents the average of leaching plots of 18, 12 foot x 12 foot, basins.

	#1, Photo 32-98	2M2S	0.85	.40	120	Si.L.	Si.C.L.
	#2, " 35-126	4M2S	0.70	.40	112	" "	" " "
	#1, " "	3M2S	1.60	.80	100	" "	" " "
	GG1	"	1.50	.50	140	" "	" " "
	D-2	3M3S	—	0.55	120	Si.L.	Si.L.
	GG-2	3M2S	1.50	0.25	65	" "	Si.C.L.
	1 Photo 37-41	2M2S	.80	0.15	112	" "	" " "
	1 " 26-14	3M2S	1.00	0.25	98	" "	" " "
Soils con-	#1 " 28-34	1M23PS5	1.16	1.75	50	" "	" " "
tained high	#4 " 28-35	$1M21XP_3S_5$	0.78	0.30	116	" "	" " "
amts. of gyp. 1954	#3 " 29-38	1F22XPS5	1.10	(0.24 mean) 0.18 Final	185	Si.C.L.	" " "
	#2 " 28-35	1M12-PS5	0.75	1.25 Avg. 1.10 Final	116.5	Si.L.	Si.C.L.

Note: All except first two are double-ring infiltrometer tests with 3-5 replications. Lab. data available on leaching trials and on last 4 infiltrometer tests.

Marja 1956	Bl.6F-3-2/200	5M3QZ	2.4	0.99	15.0	L.	L.or S.L.
RKB	" " " "	3M53QZ	2.0	0.60	16.0	Si.L.or L	B or L.
All Bl.	" 6F-7-0/400	2M34QZ	4.0	0.45	17.0	Si.L." L.	Si.L.or L.
6 F	" 7-0/500	2M3	3.75	0.60	17.5	" " " "	" " "
	" 9-1/100	2M3	2.00	0.40	17.5	" " " "	" " "
	" 11-2/300	4M3QZ	2.00	0.60	16.5	" " " "	" " "

Name of Project Area	Location	Soil Symbol	Infiltration Data: Initial Rate in./hr.	Final Rate in./hr.	Hours Test Run	Average of Texture Represented: Top Soil	Sub-Soil
Marja 1956							
RKB	Bl.6/F13-1/800	2gS3	4.00	0.50	16.0	S.L.	Si.L.
	" " 13-2/500	2M56	2.50	0.60	17.5	L	SLorLS
	" " 19-2/500	2M3	2.40	0.40	17.0	SiLorL	SiLorSCL
	" " 19-3/200	5S5QZ	5.00	1.80	12.0	S.L.	SLorLS
			3.20	0.90			
1952	S46-W52	2S43	2.2	1.0	25.0	S.L.	S.L.
CPS	" "	2M43	2.7	1.9	24.0	SiLorL	S.L.orSCL
	S36-W54	3S5QZs3	2.2	1.25	22.0	S	Sor L.S.
	S40-W52	4M42QZ	1.35	0.27	22.0	Lor Si.L	SLor SCL
	S40-W54	2M4	1.05	0.70	20.	" " "	" "
Note: 1952 tests are averages of 2 replications, 1956 tests are averages of 3 replications. Both are made with double rings.							
Had-i-Ali 1952-53 CPS	#22	4Mg^{9}4Z	1.50	0.75	23	SiL or L	L or SCL
		4Fg4Z	2.25	0150	13	SiC.L.CL	" " "
		4Fg4Z	2.50	0.30	23	" " " "	" " "
	#3		2.50	0.25	24		
	#17	4Fg^{9}4	1.25	0.25	24	" " " "	" " "
Irrigation Trials by R. D. Flannery 1956	*L.40 Sub 11 S.end FD10	2Mg^{9}34ZR	3.00	1.00	24	SiL or L	Gr.LorSiL
	L.40 Sub L2 S.end FD10	2F$^{9}_{8}$g4Z	3.50	0.20	24	SiCL "CL	SL or CL
	#4	2F3$_{g}$4Z	0.75	0.20	24	" " "	" " "
	L.40 Sub L1 N.end FD10	3S5$^{98}_{g}$4R	3.00	1.00	24	S.L.	S.L.
	#6	3F3$_{g}$4Z	2.50	0.35	24	SiC.L. or C.L.	Si.L. or S.C.L.
	L.40 S.L.K FD-1	3M3$_{g}$3QZ	.82	.50	3.5	L.or SiL	L or SiL
	L.40 S.L.B FD-6	2M2$_{g}$3S	.27	1.7	1.7	" " "	SCL or CL
	L.54.75A FD-5	2M3$_{g}$3S	.66	1.4	2.5	" " "	L to C.L.
	L.56.1 SL 4 FD-7	2M3g2S	—	.5	1.50		" " " "
	L.448 SL G FD-1	2M3g2S	.20	.24	1.66	" " "	" " " "
	L.48.8 SL B FD-6	2M3g2S	.46	.80	2.75	" " "	" " " "
	L.52.84 SL A FD-6	2M3g3S	.57	1.00	1.00	" " "	" " " "
	L.56.1 SL C FD-1	3M3g2NS	.48	.64	2.00	" " "	" " " "
	L.40 SL F FD-5	2F3g3S	.38	.80	2.2	C.L. or Si.C.L.	L to C.L.
	L.40 SL D FD-6	2M2g3S	.39	.80	1.85	Si. L. or L.	Si C.L. to C.L.
	L.41.5 FD-6	2M3g2HS	.59	1	2.0	" " "	" " "
	*L.40 SL E FD-6	2F2g3S	.57	1.2	1.75	Si.C.L. or C.L.	" " "
*Note: Above data based on irr. trials not infiltrometers.							
Chiseled 80-acre Dr. Plots		2M342S	—	1.7	—	L to SiL	L to SCL
Disced 1952	" " " "		—	0.9	—	" " "	" " "
N. Arghandab 1953	E57/750-S-36 (Leaching trial-Mishewar)	1M32/A_x P5S5	wo/gyp.	.09	—	Si.Cl.L	SiCL-SiC.
			w/gyp.	.20	—	" " "	" " " "
S.Canal Barrel seepage tests		"Compacted Silts"		0.12		Si. L.	Wet Comp.
1956	" " "	Loose "		3.60		Si. L. (loose)	
	" " "	Gravelly soils		20.3	—	(2.5"-62.5" range)	
C.Argh. Plot 1	Photo 16-58	1M32 PS5	0.85	0.15	190	Si.L.	Si.C.L.
1956 " 2	" 16-57	1M23PS5	1.10	0.55	140	" "	" " "

TABLE 37

INFILTRATION PROPERTIES OF SOILS — June 27, 1957

FIELD STUDIES OF WATER INTAKE RATES OF S. W. AFGHANISTAN SOILS

Group (Textural)	Textures Included	Normal Soils 1/		High Sodium Soils 2/			
				With Gypsum 3/		Without Gypsum 4/	
		Mean Initial 5/	Mean Final 6/	Mean Initial	Mean Final	Mean Initial	Mean Fin.
Mod. Coarse Textured 7/ (36)	Loamy Sands to Sandy Loams	Norm= 2.45 Max.= 4.65 Min.= 2.30	Norm=1.00 Max.=1.84 Min.=0.55	No Data			
Med. Textured Soils (144)	Loams, Sandy clay loams, Silt loams	Norm=2.15 Max.=3.65 Min.=0.95	Norm=0.45 Max.=1.50 Min.=0.25	Norm=1.15 Max.=2.25 Min.=0.60	Norm=0.30 Max.=1.75 Min.=0.04	Norm=1.00 Max.=2.50 Min.=0.60	Norm=0.15 Max.=0.25 Min.=0.04
Mod. Heavy-Textured (62)	Clay loams, Silty Clay loams	Norm=1.55 Max.=3.25 Min.=0.60	Norm=0.28 Max.=0.65 Min.=0.18	Norm=1.15 Max.=2.00 Min.=0.60	Norm=0.20 Max.=0.55 Min.=0.06	Norm=1.00 Max.=2.00 Min.=0.60	Norm=0.10 Max.=0.19 Min.=0.05
Heavy-Textured Soils (24)	Silty Clays to Clays	No Data - -		Norm=0.75 Max.=1.50 Min.=0.70	Norm=0.06 Max.=0.20 Min.=0.03	Norm=1.50 Max.=2.00 Min.=0.50	Norm=0.045 Max.=0.09 Min.=0.02

Footnotes: Data is taken from double-ring infiltration tests, basin leaching trials and irrigation trials.

1/ Normal soils containing generally less than 15% exchangeable sodium.
2/ Containing more than 15% exchangeable sodium.
3/ Gypsum added or present in fair to high quantities.
4/ Generally no gypsum added - may or may not be present in soil.
5/ Rate during first few minutes to one hour.
6/ Steady rate achieved after several hours run.
7/ Numbers in parentheses indicate the number of tests or combinations of tests used in computing the values given in the table.

soils - 1.00"/hr., medium-textured soils-0.45"/hr., moderate heavy textured soils-.28"/hr. Not enough data was available for normal sands or clays.

Permeability is determined in the soils laboratory as a regular procedure using the prepared samples under constant head as described in U.S.D.A. Handbook No. 60. Drawing LD 121, summarizes the final or basic permeability as determined by this method. Compared with this technique the field estimated permeability, shown in dashed lines, gives higher values for light-textured and lower values for heavy textured soils.

(2) Saturation Percentages and Water-holding Capacity

Ability of the soil to retain water for plant use is highly important in irrigation farming. The total readily available moisture that a soil will release before any section of the root zone of a growing crop begins to suffer determines the frequency of irrigation and the irrigation design necessary. Several thousand soil samples have been analyzed. The summary of these with respect to saturation percentage, textural grade and available moisture in inches per foot is given in Drawing LD 115. For convenience the field permeability index as estimated from field examination of soils is given. From these relationships and soil depths and volume weights, the total readily available moisture at field capacity has been computed for all soils mapped. Values ranged from less than 1.0" for very shallow, very gravelly or extremely coarse sandy soils to over 9.0" for very deep, medium to moderately heavy-textured soils. All soils with less than 1.5" of readily available moisture capacity were classed as non-irrigable.

c. Associated or Site Factors affecting Use, Present and Potential Use Capability and the Difficulty and Cost of Reclamation.

Site factors refer to those conditions that are not necessarily a soil property but modify the behaviour of the soil or the particular soil site. These factors include salinity and alkalinity, ground water tables, topography, flood or erosion conditions and hazards, and presence of loose stones and cobble. Temporary or removable conditions, such as a hummocky condition removable by leveling, or loose stones or salts which may be removed by leaching, are considered as "temporary limitations" and affect the present but not potential land classification. On the other hand flood hazards,or the constant threat of erosion, or a recurrent salinity condition caused by a non-removable high water table would require not only immediate attention but consistent and careful application of one or more special practices or measures to control these conditions. Such site factors do limit the potential use capability of the land and are so considered. The various site factors considered and their extent are discussed below.

(1) Leveling

Efficient use of water involves spreading it evenly over the land to be irrigated. This means more uniform crop growth and yields. High spots dry up before other parts of the field need water. If the soils have a tendency toward temporary, perched water tables, these high spots are focal points for salts to accumulate. These in turn create greater moisture stress and plants suffer for moisture even though the soil may have more than a non-saline spot nearby. Low spots receive too much water, the plants suffer for lack of aeration, the soils puddle and bake, and poor growth results.

This fact is brought out by Table 3, showing the annual consumptive use per acre evaluated for a large project recently planned. The farm delivery requirement is 4.3' and diversion requirement 5.4' for the year and the consumptive use 33" rather than 43.2" as calculated on the basis of 100% in crops all months.

b. Rainfall -

The "rainy" season is from December through April with occasional showers in November and May. Commonly the sky is clear and the air dry from mid-May to Mid-November. At irregular intervals the months of June and July will be cloudy in the eastern half of the area because of the pressure from the monsoons of the south central Asia lowlands. On very rare occasions, as in July, 1956, the monsoons break over the mountain ranges separating the Indus and Helmand watersheds and heavy rains fall in the months of June and July on the eastern slopes. Tremendous sheet and gully erosion was caused by the 1956 rains and silt loads carried by the streams were of record proportions.

Commonly 75-80% of the rains fall in January to March, inclusive, and about 15-16% in December and April. High intensity rains have been recorded. Tremendous sheet flow occurs on the scantily vegetated, desert fans which extend long distances out from the rugged, barren foothills toward the valleys and stream channels.

Mean monthly and mean annual rainfall for all stations is shown in Table 4. The stations are arranged in order of elevation and except for Ghazni there is a fair relationship. The range is from 2.8" for the Chakansur Basin Area at 490 meters elevation to 13.43" for the Kabul Valley at 1,790 meters elevation. The desert projects now being developed range from 4.81" to 7.29" annual precipitation. Considering that all of the rains fall in the winter and early spring months when temperatures are at their lowest, all rains over 0.2" are shown as effective in reducing evapo-transpiration or adding to soil moisture. The range is from 3.5" to 5.3" in the project areas being planned.

c. Evaporation -

Evaporation data, Table 5, was not taken by uniform methods and the summaries and comparisons can only be sketchy at best. Arranged in order of elevation, Marja, Kajakai and Kabul data fail to follow the general trend. There are 37" difference between Arghandab and Kajakai records although the stations are both in narrow valleys only a few miles apart and not greatly different in elevation. The mean daily July evaporation is 0.455" which is the maximum for the year and .067" in January is the lowest. The Chakansur basin records show annual evaporation of 115" and Arghandab records show an annual evaporation of 64".

d. Wind Velocity and Evaporation Relationships -

A study of wind velocity, temperature and evaporation relationships was made using the Meyer formula 1/. The data available on wind velocities is given by stations in Table 6. The extremely high winds of the Chakansur during the hot months of June-September are described in the 1905 Boundary Commission report 2/, also in the Chakansur Soil Survey Report 3/.

1/ Page 168, "Applied Hydrology" - Lindsey, Kohler & Paul ms.
2/ McMuron Report - Afghanistan-Iran Boundary Survey 1903-05.
3/ Report of Chakansur Area Soils & Drainage Surveys, MKA, October, 1955.

All fields need annual leveling and smoothing for best results. Because this is an annual task of good irrigation farming it is not considered as a project land development task. In the soil survey the lands were divided into, (a) those having relatively smooth slopes so that the farmer could do most of the work except for general planing and smoothing for the initial irrigation layout, (b) those areas requiring light to moderate cuts and fills, (c) those areas requiring heavy cuts and fills and likely to be costly to develop, and (d) those considered too rough for practical development.

The survey shows that most of the available lands are relatively smooth and generally of long slopes ranging from .0005 to .005 in grade, the more common being .001-.002. Extensive areas along the Helmand Valley are hummocky, and covered with salt cedar or tough grasses (jarru). These will require extensive clearing, heavy leveling and a final re-leveling and smoothing after settling from initial irrigation. The extent of leveling and relative costs have been studied by ACU. Leveling needs of the various project areas are summarized in Table 38.

(2) Spreading and Deep Plowing Sands

In some areas such as the Marja, the Darweshan, Garmsel and Chakansur reclamation and control of lands will require the spreading of sand drifts and incorporating these sands into the soil by deep plowing. This job requires careful surveys and supervision by soils experts during the actual operations. The correct depth of plowing must be determined by study of the coarseness of the sands and the textures and thicknesses of underlying soil horizons. Otherwise costly plowing and re-leveling may be wasted effort.

(3) Brush Clearing and Grubbing

Hummock valley soils are covered by salt cedar (tamarix gallica, t. indica, t. salina) which has tough, deep roots and a heavy crown. Clearing is generally by means of a brush cutter with a bar on the front of a remodeled scraper which undercuts the heavy roots and brings them to the surface. This helps accomplish rough leveling as it knocks down and partially spreads the sands and silts piled about the brush. Jarru grass areas need deep, double-discing with serrated discs to tear up the stubborn root crowns which make leveling difficult. The extent of brush clearing is shown in Table 38.

(4) Drainage

The most critical and yet the most neglected phase of irrigation agriculture in Afghanistan is that of drainage. Through long centuries of patience, toil and experience the Afghans have learned ingenous methods of carrying water to the land. The karez as a water system is known only in this part of the globe. Despite the innumerable evidences of irrigation not one drain can be found except a very few recent ones of crude and inadequate design.

As discussed above, the desert plains soils are generally in need of drainage. Some of these lands have such shallow depths to bedrock or tightly compacted clays, adequate drainage will almost be impossible. The valley fill and terrace benches are somewhat better situated in that the soils are usually deep and drainable materials occur from 2-4 meters below the surface. In many places the aquifers are slow or stratified, however. Ground water is now 2-8 meters below the surface in most of these areas. Additional wastage of irrigation water through over irrigation or leaching will add to the water table and cause it to rise to dangerous levels unless drainage is provided.

The lower terraces and recent alluvial soils are often affected by the recharge from the stream beds. Freely draining gravels and sands allow water to move back under the land surface in high flow and to recede again during low flow. Those lands which are high enough to escape flooding may generally be drained since the underlying materials are coarse and transmit water readily. Proper outlets with suitable grades must be found and the ditches repaired and maintained after each flood.

Drainage investigations of varying degrees of intensity have been carried out on all project areas. Detailed investigations for drainage design and construction are being carried on in the Marja, Nad-i-Ali, Shamalan, Darweshan and Tarnak projects. Thousands of open pits 2½-4 meters deep, have been dug and logged and a number have been excavated to greater depths. The structure, texture and water conducting properties of each horizon have been carefully logged and the drainability of the site classified. These logs plotted in proper elevation give the slope of the ground water; depth to, thickness of and conducting properties of aquifers; depth and slope of barriers such as rock or very slowly permeable materials. Maps have been made of several projects to show the relative drainability of various sections. This work is continuing under the Drainage Engineers, and daily new information is being added.

Since this is a phase of development that may be expected to go on for years and for which constant technical service is required this report will only summarize in a general way the drainage problems so far apparent. Table 38, summarizes the ACU estimate of acres needing drainage. While these figures may be a reasonable estimate of the amount of land requiring drainage early in the development of the project, it is expected that under full development most of the lands will need some type and degree of ground water removal development. It must be emphasized that removing water from underneath the soil can be as important a phase of irrigation agriculture as proper distribution and spreading of water on the surface.

Table 39, summarizes briefly the relative degrees of drainability as classified by present information and the acreages of each class by project areas. Some idea as to the ultimate scope of the drainage job and costs may be obtained. Exact spacings, depths, types and sizes of drains, can only be determined by intensive on-site study of each farm and field, however.

(5) Salinity

Desert irrigation commonly involves problems of maintaining the proper soil conditions with respect to salinity and alkalinity. Because of low rainfall, high evaporation and high temperatures the natural leaching of soluble salts is limited. These accumulate in the soil within the first few feet of the surface. Extensive irrigation with saline waters from karezes has deposited large amounts of salts in some soils where the percolation is slow and the soils deep enough to absorb and hold the limited amounts of water applied. Over irrigation even with a good quality of water but without proper drainage has resulted in waterlogging of certain areas and eventual concentration of salts at the surface by upward capillary movement and evaporation. In the basins such as Chakansur, lower Bakwa, and lower Darweshan (old stream bed) solutes washed in by rains or brought in by flood waters have accumulated by evaporation. This process has continued since these basins or depressions were formed. Comparisons of inflow into the Chakansur basin with water quality indicate that 5 to 6 million tons of salt are deposited there each year.

"Table 39. will be forwarded later. The various sources of data from field investigations cannot be compiled in time for this report. As soon as the drainage investigations are far enough along and the data is compiled, Table 39. will be computed."

The effects of these various influences have been the salination of extensive areas and abandonment of large tracts of formerly irrigated lands because of high salinity.

(6) Alkalinity

Where the salts thus deposited are high in sodium salts in relation to to calcium and magnesium salts which remain soluble through wetting and drying, the clay fraction of the soil absorbs sodium ions in exchange for calcium and magnesium ions. This sets up a condition which may be unfavorable for plant growth and may make reclamation somewhat more difficult. In some cases where the soluble salts gradually leach out of the upper layers of soil the clays high in exchangeable sodium may disperse, lose structure and become suspended or move downward with the gravitational flow of water, and thus seal up the natural soil pores. In extreme cases the soils may be almost impervious. Numerous lab. and field leaching trials have been carried on to determine the extent of this condition in Afghanistan soils. A summation of lab. studies is given in Table 40. It will be noted that only a small percent (1.4%-5.4% depending on range used) of the soils are now "alkali" soils or in a poor physical and chemical condition for present use or reclamation. "Saline-alkali" soils are the most common (32.8%-42.1%). In these soils a high percentage of soluble salts including soluble calcium salts are found in association with high exchangeable sodium. Extensive tests have shown that the exchangeable sodium decreases on leaching at a somewhat slower rate than the soluble salts but nevertheless does move out. The soil permeability has remained sufficiently high, except in the heavy to silty clay and clay soils, to permit continued leaching. Most of the soils contain varying amounts of natural crystalline gypsum as well as large quantities of calcium carbonate. The presence of gypsum improves the permeability of soil and also decreases the exchangeable sodium at higher rates. Such soils have given little difficulty in leaching trials. The addition of gypsum to leaching plots has been effective in the heavier soils of low initial gypsum content but has not made much difference on other saline-alkali soil conditions. It appears that given reasonable drainage most of these soils can be reclaimed for use. In the interest of project development, however, the majority of the highly saline-alkali soils have been rejected and only about 1/5 deferred for future reclamation. (See Table 41). These areas lie over more permeable substrata and are commonly soils of moderately light to medium texture and fair to very good permeability. Chapter V , Section 3, discusses in detail the necessary steps involved in reclamation of these soils.

(7) Boron in Soils

Boron may cause injury to some plants when concentrations are above 3 ppm and is toxic to most all plants at concentrations above 100 ppm. (See Table 49 , Chapter V, Section 3.) Analyses of a number of soils in the projects show boron present. About 7 % of the samples analyzed had boron in concentrations greater than 15 ppm, 25% between 5 and 15 ppm and 68% less than 5 ppm. Most common field crops grown here are not seriously affected by concentrations below 5 ppm.

Leaching trials show boron salts move out more slowly than the other soluble salts but more rapidly than the rate exchangeable sodium decreases in a saline-alkali soil. Where 1-2 acre-feet of leaching water per foot of soil usually suffices for normal leaching, high boron soils may require 3-4 acre-feet per foot and thus require longer to reclaim. (See Chapter V, Section 3 on treatment of high boron soils.).

Table 40. **SUMMARY OF SALINE AND ALKALI CONDITION OF ALL LABORATORY SAMPLES TO DATE** 3/18/57

The following summary is based on the characteristic of saline and alkali soils as defined in Agriculture Handbook No. 60, "Diagnosis and Improvement of Saline and Alkali Soils".

The scale of conductivity and E.S.P. has been adjusted to include the ordinary Afghan field crops which have a higher relative tolerance of salts:

Non-Saline - Saturation Extract - Less than 10 millimhos/cm
pH " " - " " 8.5
E.S.P. (Exch. Na pct.) less than 20%

Saline - Saturation Extract - Greater than 10 millimhos/cm
pH " " - Less than 8.5
E.S.P. " - Less than 20%

Saline-Alkali - Saturation Extract - Greater than 10 millimhos/cm
pH " " - Less than 8.5
E.S.P. " - Greater than 20%

Non-Saline Alkali - Saturation Extract - Less than 10 millimhos/cm
pH " " - Greater than 8.5
E.S.P. " - Greater than 20%

	Non-Saline	Saline	Saline-Alkali	Non-Saline-Alkali	Total
Arghandab	150	11	36	20	217
Chakansur	46	6	71	6	129
Darweshan	28	9	79	1	117
Dasht-i-Bakwa	128	3	15	1	147
Kajakai	47	0	0	2	49
Lashkarga	40	7	59	9	115
Marja	150	68	16	2	236
Nad-i-Ali	497	31	180	46	754
Seraj	350	30	225	14	619
Shamalan	283	16	288	68	655
Tarnak	30	38	73	5	146
	1749	219	1042	174	3184

Percent of salinity or alkalinity when scale of conductivity is adjusted to 10 millimhos/cm and the E.S.P. to 20%:

Non-Saline	55.0 %	of all samples
Saline	6.8 %	" " "
Saline-Alkali	32.8 %	" " "
Alkali	5.4 %	" " "

Percent of salinity or alkalinity when scale of conductivity is adjusted to 4 millimhos/cm and E.S.P. to 15%:

Non-Saline	35.0 %	of all samples
Saline	21.5 %	" " "
Saline-Alkali	42.1 %	" " "
Alkali	1.4 %	" " "

March 5, 1957

Table 41 A STUDY OF THE RELATION OF SOIL SALINITY AND ALKALINITY TO CLASSIFICATION OF SOILS MAPPED IN HELMAND BASIN

Area	Total Surveyed Area	Lands Irrigable Now: No salinity or alkalinity affecting crops	Lands Irrigable Now: Slight to moderate salinity & alkalinity crops do well	Lands Irrigable After feasible reclamation: No salinity or alkalinity 1/	Lands Irrigable After feasible reclamation: Salinity-alkalinity moderate to severe	Non-Irrigable or not recommended: Not Saline-alkali 3/	Non-Irrigable or not recommended: Mod. to Very severe saline-alkali
Tarnak Acres	110,656	23,270	36,507	——	10,168 2/	22,590	18,121
" %	100	21.11	32.90	——	9.19	20.42	16.38
Darweshan Acres	73,910	32,060	10,708	2,243	4,320	17,237	7,342
" %	100	43.4	14.5	3.0	5.8	23.4	9.9
N. Arghandab Acres	67,685	28,425	7,018	689	7,602	17,730	6,221
" %	100	42.0	10.4	1.0	11.2	26.2	9.2
C. Arghandab Acres	132,220	48,607	29,478	——	9,340	26,400	18,395
" %	100	36.7	22.3	——	7.0	20.0	14.0
Nad-I-Ali Acres	25,000	11,366	3,594	——	5,664	1,553	2,823 4/
" %	100	45.5	14.4		22.7	6.2	11.3
Marja Acres	49,902	15,120	3,502	1,881	9,166	10,225	10,552
" %	100	30.2	7.0	3.8	18.4	20.5	21.2
Shamalan Acres	65,000	23,352	10,375	——	10,645	(5,000) 5/	15,628
" %	100	35.9	16.0	——	16.4	7.7	24.0
Seraj Acres	105,908	32,063	24,737	1,015	7,229	28,042	12,822
" %	100	30.3	23.4	0.9	6.8	26.5	12.1
Lower Helmand & Chakansur Acres	554,335	75,197	35,250	18,708	18,270	84,534	324,376 6/
" %	100	13.6	6.4	3.4	3.3	15.2	58.6
Garmsel Acres	154,827	3,829	13,529	217	38,175	13,298	84,314
" %	100	3.0	9.0	0.2	24.6	8.6	54.6
TOTALS	1,339,443	293,289	174,698	24,756	120,579	226,609	500,594
% of TOTAL	100	21.90	13.10	1.80	9.00	16.82	37.38
% of Irrigable & Deferred	(613,322)	47.82	28.49	4.04	19.65	——	——

1/ Soils deferred for leveling and drainage but having no saline-alkali problems.

2/ This includes 9,065 acres of potential Classes I & II & 1,103 of potential Class III.

3/ Generally includes shallow, rocky or steep broken areas, sand dunes and gravel bars.

4/ Areas in villages included here.

5/ Estimated proportion in sand dunes and gravel bars.

6/ Based on Chakansur Soils & Drainage Survey Report showing the maximum useable land without major flood and drainage structures and erosion control.

CHAPTER V LAND RECLAMATION AND TREATMENT

F. O. Youngs in a report on the Helmand Valley Development Program, June 23, 1956, said of the problems ahead, "Many difficult problems confront those interested in developing the Helmand Valley into the productive and prosperous agricultural area it could and should be. It cannot be stressed too strongly that at present success and failure are in the balance. Only a concerted effort on the part of all agencies dealing with the development, as well as farmers and land owners, will swing the balance in the direction of success. HVA, ACU, MKA and ICA should work in the closest harmony and should give as much aid as possible to the farmers in developing the land. Difficulties are of several kinds. Some of them are inherent in the character of the soil and the lay-of-the-land. Others result from settling nomadic people with little or no knowledge of or experience in the complexities of irrigation farming and with meagre or no resources of money, equipment, seed or livestock".

Youngs devoted many years to agricultural problems of the southwest Asian deserts. With clearcut thinking he realized that the development of successful agriculture is the ultimate job of the farmer on the land. All the letter-designated agencies can do in the long run is "work in the closest harmony and ......give as much aid as possible to the farmers.....". Earlier in this report summaries of surveys and investigations are discussed which point up some of the physical jobs to be done on the land. Problems of training equipping and guiding the farmers are beyond the scope of this report. That the eventual success of the development is largely dependent on the human factor rather than soils or climate, is clearly recognized, however.

Among the physical land development problems all calling for skill, equipment and financing are land clearing and leveling, drainage, removal and control of salts and alkali, erosion and flood control and fertility management. Each project area has one or more of these tasks to do in the process of development. Some of the problems involved in each and the principles which may be used in their solution are briefly discussed here.

1. Land Clearing and Leveling. A summary of project surveys, Table 38, shows that 18,900 acres of land need clearing, 85,000 acres need light to moderate leveling, & 8,000 acres need heavy leveling. ACU estimated they would need to disc 47,000 acres and land plane 118,400 acres in addition to the above tasks.

The acreage in each of the above categories is constantly changing because there are no means of keeping abreast of what the farmers do for themselves. Irrigation in the Shamalan has about doubled the annual acreage cropped. None of this increase was due to ACU, HVA or ICA efforts. Over the entire Arghandab-Helmand system it is estimated that 130,000 more acres of land are being farmed now than before development started. Of this acreage 12,500 in the Nad-i-Ali and about 6,000 in the Marja are direct results of the government's program.

The common brush to be cleared is salt cedar. A heavy cutter bar on a suitable frame is pulled beneath the surface deep enough to cut off the heavy roots and bring them to the surface. Salt cedar will re-invade an area quickly, however. Control of salt cedar as well as other plants will be a continuing job for the farmer after the land is under irrigation. The salt cedar withes are woven into mattes and baskets, the tough stumps and roots are used for firewood.

Considerable discussion has been given to the problem of leveling because of the costs involved. Actually, leveling equipment for finishing the farm fields into shape for efficient irrigation is lacking. Most of the leveling work done so far has accomplished only the major leveling into different levels or lands. The surface is left with quite irregular micro-relief that must be smoothed and floated before water can be spread evenly. No attempts have been made, except on a few government tracts, to level to a finished grade with ± 3 centimeters, tolerance.

The assumption has been that leveling need only be enough to provide water for irrigating the small check basins so commonly used by Afghan farmers. Grading is done in planes with ± 8 cm. tolerance. It is expected that the farmer will eventually level and smooth the soil within each basin. Unfortunately, this is not always accomplished. Over irrigation of some basins is a common practice while others receive little water.

More attention needs to be paid to the depth and texture of soils in determining safe cuts and fills. Much of the Nad-i-Ali and Marja land is composed of relatively shallow soils. Cuts over 4"-6" may leave the remaining soil so thin it is not suitable for irrigation. In such areas smoothing and layout of smaller contour check basins may help to get better distribution and with minimum leveling. Moderately deep to deep soils of the desert plains soil (Seraj, Marja, Nad-i-Ali, Upper Tarnak, Upper N. Arghandab) will allow leveling for contour border or check border irrigation. In all cases effort should be made to see that feeder ditches leading into borders or check basins can put the amount of water needed into each border or border-check in minimum time in order to decrease percolation losses. The deep and very deep river terrace and valley fill soils will ordinarily stand fairly heavy cuts. Generally grass or brush-covered land will be quite hummocky and heavy leveling will be needed.

The type of irrigation layout best suited to an area will vary with the soil and general slope as well as the types of crops to be grown. No single set of rules will suffice for a large area. For guidance of design based on soil characteristics, layout data is given in Chapter VII "Tillage and Water Use Practices", for the major soils.

2. <u>Drainage</u>. The extent of land areas affected by drainage was discussed in Chapter IV, Section 3 . It was pointed out that this phase of land development is probably the most serious one in the Helmand Valley program. Some of the principles of drainage as they affect crop production or briefly discussed here.

a. <u>Plant tolerance to ground water</u> - plants vary widely in growth requirements. Many common field crops and trees do best on deep, well-drained permeable soils which allow free root movement and permit air to the roots at considerable depths. Some plants have shallow root systems or may readily adapt a shallow root system permitting higher water table levels. Some plants will grow directly in water and have the ability to take up air as needed from the water or through other parts of the plant above water. In rice culture, once the seedlings are established, the plants may stand in 3"-6" of water throughout the growth period. The problem of drainage becomes, therefore, one of adjusting the factors of drainability and costs of drainage against the expected benefits from crops adapted to different levels of drainage.

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TABLE 3

AVERAGE EFFECT OF CLIMATE ON IRRIGATION REQUIREMENTS IN S. W. AFGHANISTAN
(Avg. of 10 Stations)

June 23, 1957

Month	t 1/ Mean Mo. Temp. °F	2/ % P Sunshine Hours	$f = \frac{tP}{100}$ Consumptive Use Factor	Avg. Mo. 3/ Cons. Use = kf (k = 0.65) inches	Weighted 4/ Cons. Use per acre including Double-Cropping inches	Farm 5/ Irr. Req. @ 55 of Eff. A.F./Acre	Res. 6/ Release Req. @ 80% A.F./Acre
Jan.	41.6	7.22	3.00	1.95	1.00	none	none
Feb.	46.5	6.99	3.25	2.11	1.25	0.04	0.05
Mar.	55.8	8.37	4.67	3.04	2.25	0.14	0.18
Apr.	66.0	8.74	5.77	3.75	3.50	0.45	0.55
May	76.1	9.60	7.31	4.75	4.75	0.69	0.85
Jun.	82.6	9.57	7.90	5.14	4.00	0.61	0.75
Jul.	87.1	9.74	8.48	5.51	5.50	0.83	1.05
Aug.	83.0	9.27	7.69	5.00	4.00	0.61	0.75
Sep.	74.4	8.34	6.20	4.03	3.00	0.45	0.55
Oct.	62.9	7.95	5.00	3.25	1.25	0.19	0.24
Nov.	54.2	7.13	3.86	2.51	1.50	0.20	0.25
Dec.	47.1	7.08	3.33	2.16	1.00	0.10	0.13
Totals	777.4	—	—	43.20"	33.00"	4.30'	5.40'
Means	64.8	—	—	3.60"	2.75"	0.36'	0.45'

Footnotes:

1/ Data from 10 stations, elevations; 540-2240 meters; 3-44 years records.

2/ Sunshine hours at 31° 30' N. Latitude.

3/ Average k of .65 used for crops grown in the area.

4/ This represents mean per acre consumptive use based on % of land in various crops and stage of growth. Includes double cropping.

5/ Cons. Use - rainfall ÷ .55 = farm irrigation req. at avg. assumed efficiency.

6/ Delivery losses are 75%, return flow usage = 5%.

SOIL AND WATER RESOURCES OF SOUTHWEST AFGHANISTAN

A study of soils, climate, drainage, and agriculture summarizing present and potential irrigation development and the problems of development.

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APPENDICES